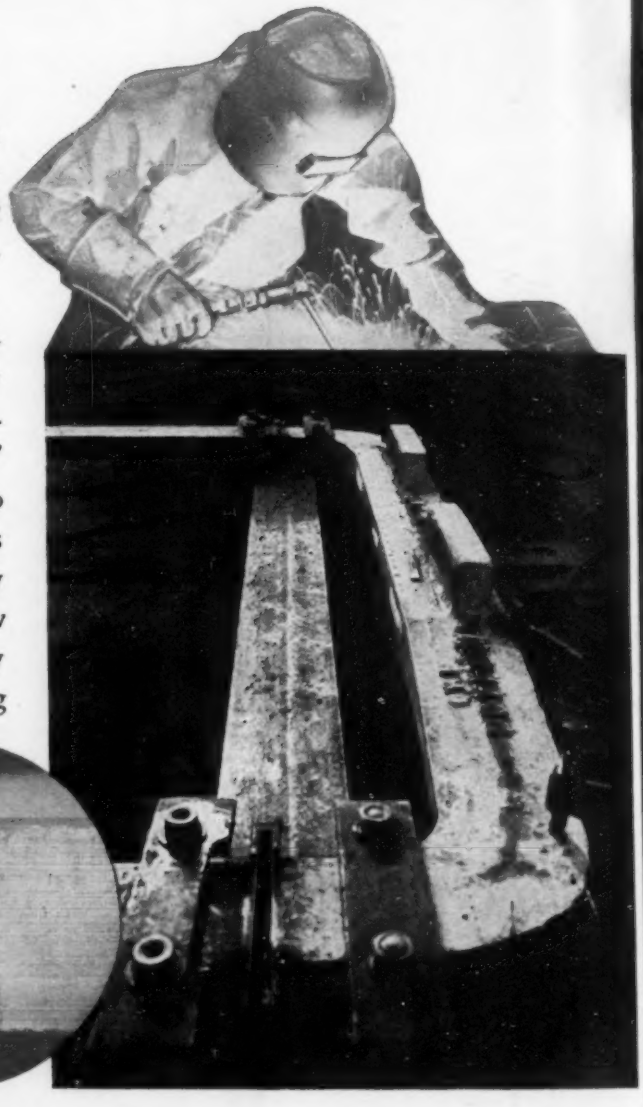
ENGINEERING LIBRARY

MARCH, 1948

The WELDING Journal

The Journal of the American Welding Society

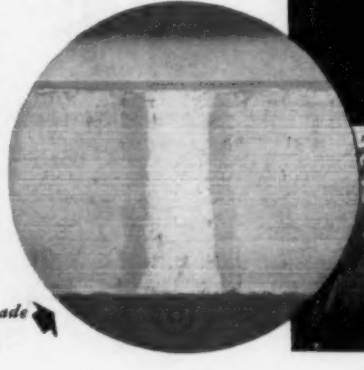
FHP *SPEEDS*
BALDWIN LOCOMOTIVE PRODUCTION



● Using the correct M & T electrode . . . plus a wealth of welding "know-how" is the combination that consistently produces high speed, high quality fabrications at low cost in the Eddystone plant of the Baldwin Locomotive Works.

An excellent example is their production line manufacture of water-space frames . . . or mud rings as they are more frequently termed. These frames, used in locomotive boiler assemblies range from 4′ x 5′ up to 10′ x 22′ in size and are made from bars 4″ to 8″ in width and 3″ to 5″ in thickness. All welding is done in straight-sided gaps with 5/16″ Murex Type FHP electrodes at approximately 600 amperes . . . an overloading of current which few electrodes will withstand. Results however, are extremely high speed operation with no sacrifice whatever in welding quality . . . a neat trick but daily routine at Baldwin where welding ingenuity and M & T electrodes combine to provide welding speed, quality and economy.

Want literature covering the entire M & T line? Write today.



Cross section of straight gap weld made with FHP in Locomotive mud ring.

METAL & THERMIT CORPORATION
120 Broadway · New York 5, N. Y.

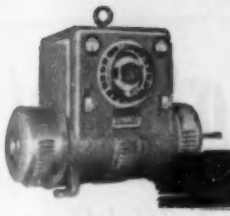
ALBANY · CHICAGO · CINCINNATI · CLEVELAND · HOUSTON · MINNEAPOLIS · NEWARK
PHILADELPHIA · PITTSBURGH · SO. SAN FRANCISCO · TORONTO

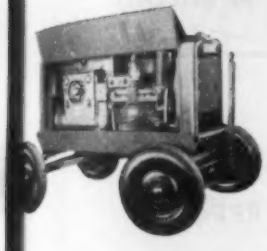
MUREX WELDING ELECTRODES
M&T ELECTRODES and GAS RODS
M&T WELDING ACCESSORIES

MORE SPEED! BETTER WELDS . . . . FASTER!

HOBART

"One of the world's largest builders of **ARC WELDERS**"





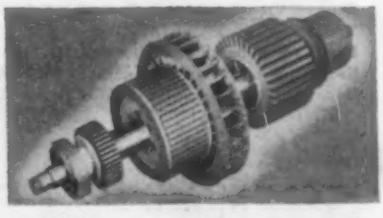
gives you the really profitable arc welding advantages at no extra cost!

To meet increasing demands imposed on your business by competition and production, avail yourself of the hard-to-beat advantages offered by Hobart Welders with complete accessory equipment.

You'll be amazed at the variety of Hobart Welders which have been specifically designed to answer your requirements. Smooth running under hours of continuous use and heavy load, Hobart Welders give you maximum performance at minimum cost. Accurate control of welding heat. Sturdy, precision-built equipment and a wide range of adaptability enable you to cut production costs and out-produce competition! Insist on Hobart Welders for the good years ahead. **HOBART BROTHERS COMPANY, BOX WJ-38, TROY, OHIO.**

1000 COMBINATIONS of welding heat. Just dial the right heat . . . no guessing!

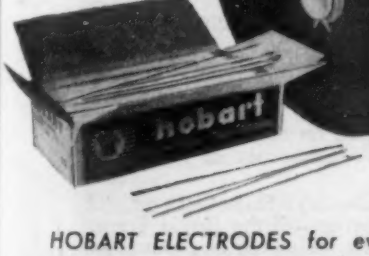
The modern design of dual control gives you selection of welding range, control of voltage and current for best welding performance . . .



HOBART runs COOLER . . . Specially designed inbuilt fan cools armature, generator parts, assures rated performance

Exclusive Remote Control enables easy regulation of weld heat on-the-job at any distance from the welder

Convenient Polarity Switch to suit different types of electrodes you will use.



HOBART ELECTRODES for every purpose. Improved and perfected for each specific job.

free

•HOBART BROTHERS COMPANY, BOX WJ-38, TROY, OHIO

Send me more details about Hobart Arc Welders and explain why I get more for my money with HOBART.

NAME _____

FIRM _____

ADDRESS _____

The Journal of the American Welding Society

Published for the Advancement of the Science and Art of Welding

W. SPRARAGEN, Editor

MARCH 1948

VOLUME 27 NUMBER 3

OFFICERS—1947-1948
President, H. O. HILL
First Vice-President, G. N. SIEGER
Second Vice-President, O. B. J. FRASER
Treasurer, R. S. DONALD
Executive Secretary, J. G. MAGRATH
Secretary and Asst. Treasurer, M. M. KELLY
Technical Secretary and Handbook Editor, SIMON A. GREENBERG

District Vice-Presidents
District #1 (New York & New England)—GEORGE M. TREFTS, III
District #2 (Mid-Eastern)—HARRY W. PIERCE
District #3 (Southern)—R. E. LORENTZ, JR.
District #4 (Central)—G. O. HOGLUND
District #5 (Mid-Western)—J. R. WIRT
District #6 (Mid-Southern)—HOWARD N. SIMMS
District #7 (Western)—GILBERT S. SCHALLER

COVER

Inert Gas Welding Stainless Steel Sink from New G. E. Movie.

ISSUED MONTHLY

Copyright 1948, by
The American Welding Society

Subscriptions $5.00 per year in United States and possessions; Foreign Countries $7.00. Single copies, non-members $.75; Special issue October $1.00; members 50 cents.

Entered as second-class matter January 15, 1932, at the post-office at Easton, Pa., under the act of March 3, 1879.

PUBLICATION OFFICE
20th & Northampton Streets, Easton, Pa.
EDITORIAL AND GENERAL OFFICES
33 West 39th St., New York 18, N. Y.

The Society is not responsible for any statement made or opinion expressed in its publications. Permission is given to reprint any article after its date of publication provided proper credit is given.

CONTENTS

TECHNICAL PAPERS, ITEMS AND REPORTS

Powder Cutting as a Production Tool, by D. H. Fleming 181
Oxyacetylene Production Cutting in Steel Mills, by A. H. Yoch and W. Begerow 188
Current Welding Literature 192
Adams Lecture for 1947—Structural Strength of the Welded Joint, by G. S. Mikhalapov 193
A Clinical Approach to Weldment Design, by Gerald von Stroh 207
Welding and Fabrication of High-Temperature Alloys, by C. G. Chisholm 217
French Specifications for Gas Welding Rods 223

SOCIETY AND RELATED ACTIVITIES

Standard Rules for Field Welding of Steel Storage Tanks 225
Proposed Amendments to By-Laws of the A.W.S. 225
Kinzel Made President of Carbide Labs. 226
Welder Service Company 226
Obituary 226
Welded Structure 227
Airco Pacific Appoints 4 New Vice-Presidents 227
INDEX TO ADVERTISERS 230
Running a Machine Shop 232
New Electrode Wall Chart 232
Eureka Alloy Welding Electrodes ... 232
Third Southern Machinery and Metals Exposition to Be Held in Atlanta, Georgia, April 5-8, 1948 ... 232
Annual Meeting, Society for Experimental Stress Analysis 234
Welding Fittings 234
Salvage of Castings 234
New Page Gas Welding Wire Catalog 234
Pleasure Cruisers 234
Motion Picture—"Welding Comes to the Farm" 236
Ten-Year-Old All-Stainless Steel Santa Fe Coach Passes Severe Tests 238
New Safety Directory 238
Freight Car Assembly Line 240
Use of Electric Welding in Industry . 242
Leston V-P in Charge of Production . 242
Resistance Welder Mfrs. Assn. Elects New Officers 242
Welding Thick Aluminum 244
Air Reduction Announces New Technical Sales Appointments 244
New Products 246
Metal Process Engineering 248
Abstracts of Current Welding Patents 250
Section Activities 254
Origin and History of the Milwaukee Section of the A.W.S. 266
List of New Members 270
Radiograph Competition 270
Iron & Steel Exposition 270
Employment Service Bulletin .. 271
Bulletins on Aluminum Bronze Cold Heading Alloy 271
Sustaining Member 271
New Resistance Welding Catalog .. 271
Stainless Steel Handbook 271
1948 Annual Meeting of the American Society for Testing Materials . 271
Bronze Welding Procedures 272
Welding Helps for Farmers 272
Magnesium and Its Alloys 272

WELDING RESEARCH SUPPLEMENT

Development of Cleavage Fractures in Mild Steels, by A. B. Bagsar ... 97-s
Cleavage Fracturing and Transition Temperatures of Mild Steels, by A. B. Bagsar 123-s
Printer's Mixup 131-s
Some New Aspects of the Fatigue of Metals Brought Out by Brittle Transition Temperature Tests, by C. W. MacGregor and N. Grossman 132-s
Discussion of the above paper, by D. Swan 143-s
Authors' Reply 144-s
The Effect of Variation in Notch Severity on the Transition Temperature of Ship Plate Steel in the Notched Bar Impact Test, by R. S. Zeno and J. R. Low, Jr. 145-s
Extent of Peening Weld Deposits for Stress Relief, by Joe Lawrence Morris 148-s
Authors' Reply to Dr. Finn Jonassen's Discussion of Paper "Distribution of Strength and Ductility in Welded Steel Plate as Revealed by the Static Notch Bar Tensile Test." ... 158-s
Authors' Reply to Dr. Finn Jonassen's Discussion of Paper "Effect of Section Size on the Static Notch Bar Tensile Properties of Mild Steel Plate." 159-s
Supplementary Statement on "A Comparison of the Brittle Transition Temperatures as Determined by the Charpy Impact and the M.I.T. Slow-Bend Tests," by C. W. MacGregor and N. Grossman 159-s

The Journal of
The American Welding Society
VOLUME 27 · NUMBER 3 · MARCH 1948

Powder Cutting as a Production Tool*

By D. H. Fleming†

POWDER CUTTING has become well established in the metalworking industry during the past several years in the cutting of stainless steels and other materials difficult to process by standard oxyacetylene methods. It is now considered as a production tool to work the product from the ingot to finished form. The companion process of powder scarfing, while not being covered in this paper, is on the same footing for a number of applications. In addition to production operations on stainless steel the powder-cutting process is also being used on cast iron and materials of very high alloy content. This paper will be confined, however, to stainless steel.

The fundamentals of the process are known and need not be covered in detail. Briefly, the process consists of introducing a finely divided iron-rich powder into the cutting-oxygen stream. The powder unites with the oxygen and burns, liberating large quantities of heat and forming superheated molten particles of iron oxide. This additional heat supplied by the burning powder plus the fluxing action of the superheated particles keeps the refractory oxides, formed in the oxidation of the stainless steel, in a molten condition to be ejected in the slag stream.

When the process is being considered as a production tool a number of factors must be studied to determine its adaptability:

1. First and foremost is the cost of doing the job, since the process must show savings under normal operating conditions over other methods of accomplishing the same result.
2. A second consideration is the effect of the cutting process on the physical properties of the material, since unstabilized stainless steels are subject to carbide precipitation when heated to the critical-temperature range.
3. The equipment required to do the job must be adequate and easy to operate.

Each of these factors must be analyzed in order to determine where powder cutting may best be applied.

* Presented at Twenty-Eighth Annual Meeting, A.W.S., Chicago, Ill. week of Oct. 19, 1947.

† Development Engineer, The Linde Air Products Co.

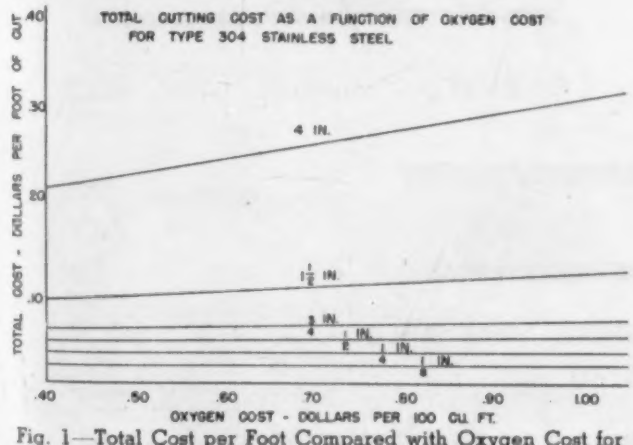


Fig. 1—Total Cost per Foot Compared with Oxygen Cost for Various Thicknesses

Fig. 2—Powder-Cutting Operation on 1-In. Stainless Steel Plate Showing Surface and Top Edge Condition

Powder-Cutting Costs

Experience has indicated that powder-cutting costs are lower than those for other methods. In considering the cost factor, the *time* element is outstandingly in favor of powder cutting since, with the exception, of course, of straight-line shearing, this is one of the fastest methods for cutting stainless steels. The labor component of the cost consequently is small compared with previous practices, such as nibbling, multiple drilling and electric arc cutting, where labor represents the major item.

Naturally the costs for oxygen, acetylene and powder must be included. Of these, acetylene and powder costs may be considered fixed. Figure 1 shows that variations in oxygen costs have very little effect on the total cost per foot of cut in thickness from $^1/_4$ to 4 in. Unit cost for labor, powder and acetylene are fixed in calculating these cost figures. Thus it will be apparent that in the fabricating shop using relatively small volumes of oxygen compared with the steel mill, the powder-cutting costs are little if any higher.

The average cost for cutting $^1/_4$-in. thick 18–8 stainless steel is about 3 cents per foot of cut. On 4-in. material, operating at standard conditions, the cost will be about 25 cents per foot of cut. As the material thickness increases beyond 4 in., the oxygen cost becomes an increasingly greater component of the over-all cost, but acetylene cost remains substantially constant while labor and powder cost decrease at approximately an equal rate to balance out the increase of the oxygen component.

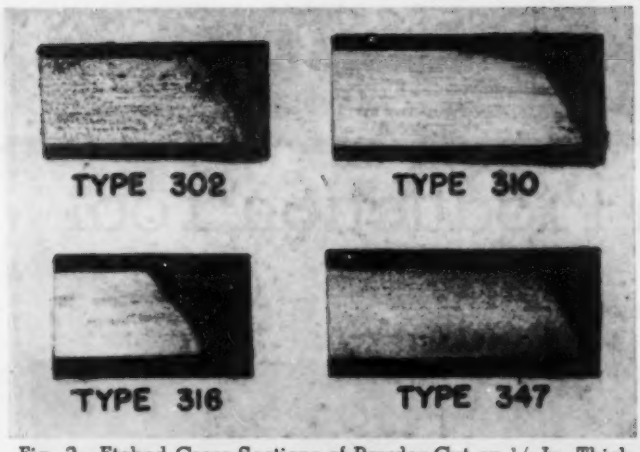


Fig. 3—Etched Cross Sections of Powder-Cut on $^1/_2$-In. Thick Types 302, 316, 310 and 347 Stainless Steel Showing Heat-Affected Area

To obtain the costs previously mentioned, the recommended practice is to use nozzles one size larger than those used on the equivalent thickness of carbon steel. In so doing, cutting speeds are the same or sometimes greater than carbon-steel cutting speeds. Some steel mills have found it advantageous to use oversize nozzles, particularly in the range of thickness from $2^1/_2$ to 7 in. For instance, ordinary practice on 4-in. material is to use a nozzle of either cylindrical or the divergent-bore, high-speed type that will pass approximately 500 cu. ft. per hour of oxygen at normal operating pressures for the particular nozzle design. For the cylindrical-bore type, the operating pressure is about 50 psi. and for the high-speed type about 100 psi. With the oversize nozzle, oxygen flows in the order of 900 to 1000 cu. ft. per hour are used.

At first glance it might appear that this would result in an increase in the cost per foot of cut, but the increased speed obtainable actually results in lower costs per foot of cut because cutting speeds are increased 50 to 100%. This gives lower unit costs per foot of cut on labor, powder and acetylene since the labor cost is naturally at a fixed hourly rate and since it is not necessary to increase appreciably the acetylene and powder flows at the higher speed. The unit consumption of oxygen remains essentially constant, the increased speed balancing out the higher flow rate. Under these specialized conditions the over-all cost on 4-in. 18–8 stainless steel per foot of cut will be approximately 26 cents per foot based on cylinder oxygen schedules. However, greater differential is shown when schedules for large-volume oxygen such as encountered in steel-mill practice are considered. In this case the cost per foot of cut will drop to 16 or 17 cents on the 4-in. material.

The use of oversize nozzles is not common in the fabricating shop because thicknesses of $2^1/_2$ to 7 in. are seldom seldom encountered. On thicknesses under $2^1/_2$ in. the use of oversize nozzles is not considered entirely practical because the quality of the cut is imparied at very high speeds. In addition, it is difficult on shape or hand-cutting operations to follow an irregular contour at high speed. Actually, on $^1/_4$- and $^1/_2$-in. material, speeds of 32 and 27 in. per minute, respectively, are easily reached with standard operating conditions. On heavy sections over 7 in. the cutting speed tends to approach a limiting value regardless of the oxygen flow used.

In addition to the direct costs of cutting, there are secondary costs that must be taken into consideration in order to arrive at a true over-all cost picture. These are concerned with the clean-up or treatment of the cut edge to make it ready for the next operation. In the cutting of stainless steel, it is characteristic that a heavier scale is formed on the cut surface than on oxyacetylene cut carbon steel. Also there will be a small protective build-up of fused powder along the top edge of the kerf, as shown in Fig. 2. This is characteristic of proper powder-cutting technique and results in a sharp top edge. This build-up should be removed with a chipping chisel or hand grinder and the scale should be ground down to a shiny metal surface. For certain types of work it may be

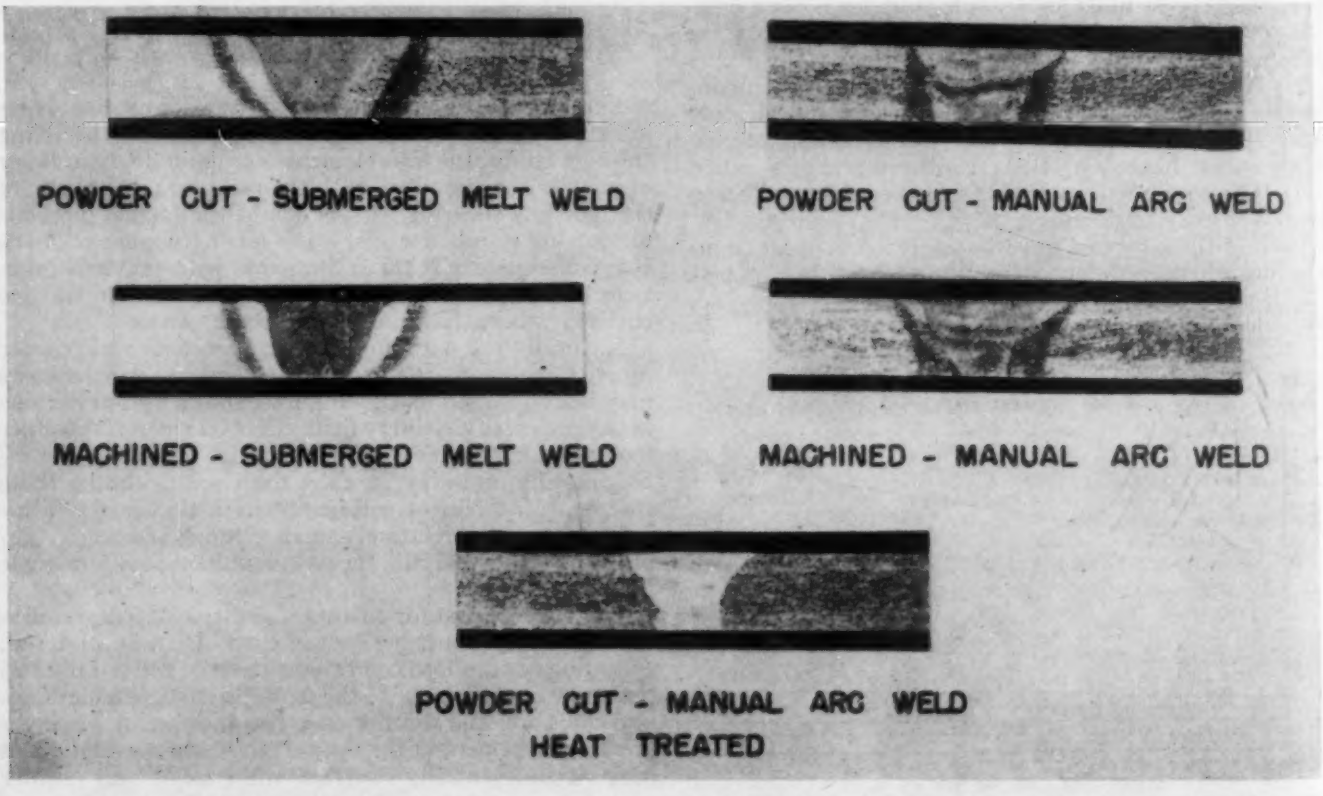

POWDER CUT - SUBMERGED MELT WELD
POWDER CUT - MANUAL ARC WELD
MACHINED - SUBMERGED MELT WELD
MACHINED - MANUAL ARC WELD
POWDER CUT - MANUAL ARC WELD
HEAT TREATED

Fig. 4—Etched Cross Sections of Powder-Cut and Welded Specimens of Type 304 Stainless Steel

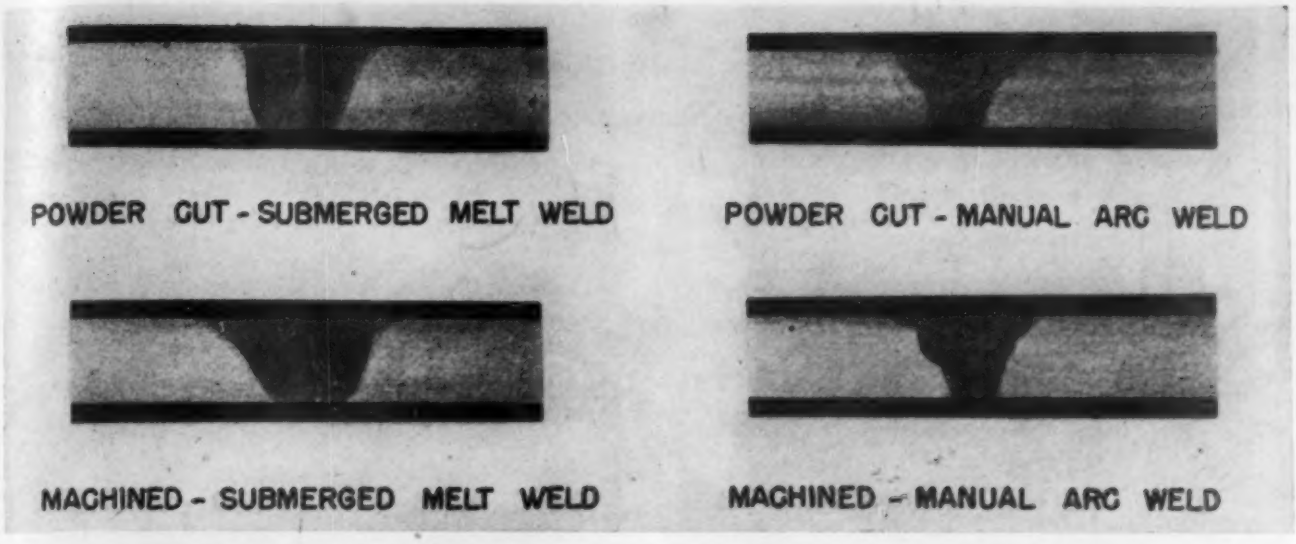


Fig. 5—Etched Cross Sections of Powder-Cut and Welded Type 347 Stainless Steel

found desirable to take a light machining cut on the powder-cut edge. While welds have been made satisfactorily on the as-cut surface, without removing scale, this practice is not recommended.

In any event, the inclusion of the cost of this secondary edge treatment in the total cost of mechanized powder-cutting edges still leaves a considerably lower cost than obtained with previous shaping methods since the cut can be made with accuracy to specified dimensions. Sufficient allowance need be made for the grinding of only a few thousandths of an inch. Secondary treatment of hand-guided powder cuts will largely be governed by the skill of the operator.

Another rather important factor is the greater recovery of scrap. Scrap pieces from which smaller parts can be cut can be obtained by judicious layout of plate following practices that are common to carbon-steel fabrication. This factor is important when working with material as expensive as stainless steel where it is imperative to utilize the maximum square footage in any given plate.

Consideration of these factors of direct cutting charges, and cost of secondary treatment minus the salvageable value of scrap places powder cutting in an extremely favorable position as a production tool as compared with previous stainless steel cutting methods. No cost comparisons are made directly with other methods in this discussion because these costs are best known to each individual plant.

Effect of Powder Cutting on Cut Edge

The effect of the powder-cutting process on the physical properties of stabilized and unstabilized stainless steels has been the subject of much study. Unstabilized stainless steels when heated in the temperature range of 800 to 1500° F. are subject to carbide precipitation at the grain boundaries, thereby making the material susceptible to intergranular corrosion. The degree of the carbide precipitation in a given material depends primarily on the time the material is held in the critical-temperature range. Susceptibility to carbide precipitation increases with an increase in carbon and decreases with increased amounts of chromium and nickel. The stabilized types 347 and 321 are essentially free from carbide precipitation.

Powder cutting is an oxidation process involving temperatures considerably in excess of 2700° F. at the kerf face. The temperature gradient drops rapidly as the distance from the kerf surface increases and under ordinary cutting conditions the critical-temperature range exists in the region of $^1/_{16}$ to $^1/_4$ in. away from the edge, with some variation depending on material thickness and cutting speed.

Much work has already been done and more is in progress to evaluate completely this problem for the benefit of the stainless steel fabricating industry and those using its products. Study has also been made to clarify the

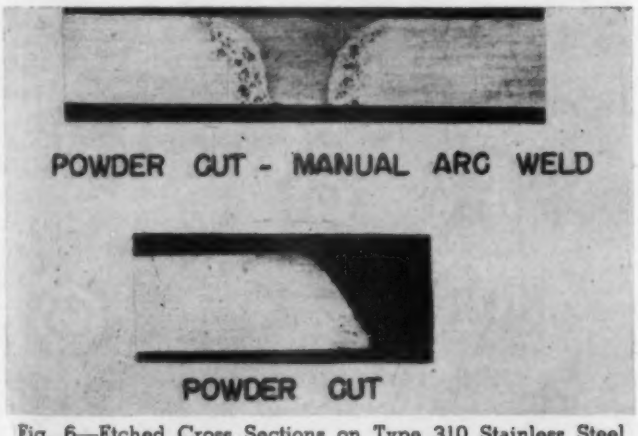


Fig. 6—Etched Cross Sections on Type 310 Stainless Steel Comparing Heat Effect on Powder-Cut Edge with Powder Cutting Followed by Welding

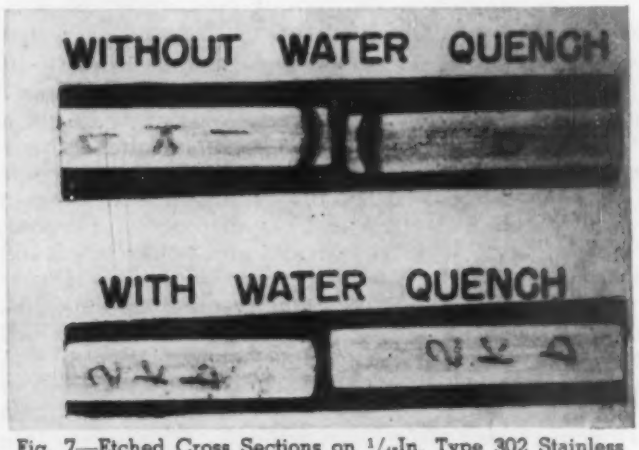


Fig. 7—Etched Cross Sections on $^1/_4$-In. Type 302 Stainless Steel Cut With and Without Water Quench

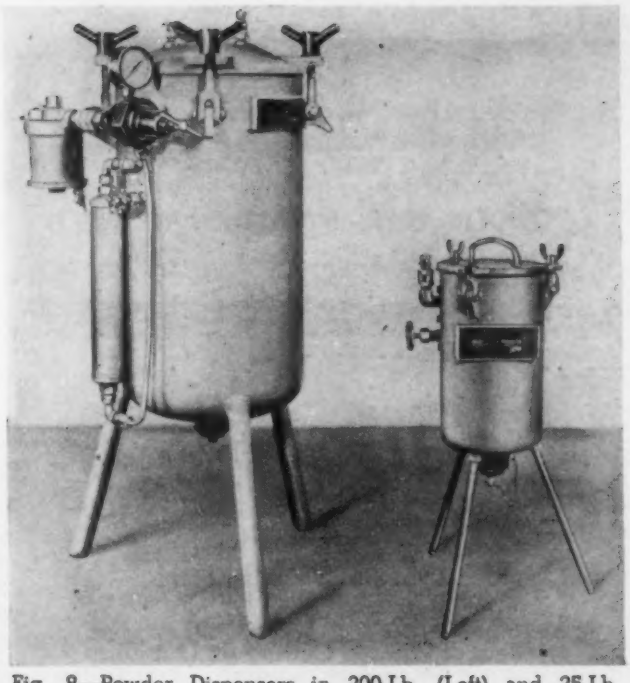


Fig. 8—Powder Dispensers in 200-Lb. (Left) and 25-Lb. (Right) Capacity

effects of combined cutting and welding. This work has consisted essentially of three phases: a study of the direct effect of powder cutting on various types of stainless steels; a study of the combined effect of powder cutting and either manual arc or submerged-melt welding; and study of methods to eliminate or minimize the heat effect.

To investigate the first two phases of this work four types of stainless steel were chosen as being representative of the broad range of stainless steel analyses. These were Type 304, an 18–8 steel with a maximum of 0.08% carbon; Type 316, an 18–12 steel with approximately 2.5% molybdenum and a maximum of 0.10% carbon; Type 310, a 25–20 steel with a maximum of 0.25% carbon; and stabilized Type 347, an 18–8 steel with 1.00% columbium and a maximum of 0.10% carbon. One-half inch thick material was used for all tests and all specimens were etched for five 1-hr. periods in a solution of 10% nitric acid and 3% hydrofluoric acid at 77° C. Cuts were made at a cutting speed of 15 in. per minute on a 30° bevel as preparation for subsequent welding.

On the as-cut edges, the three unstabilized materials exhibited varying degrees of corrosion but to the same depth. As shown in Fig. 3, Type 302 has a considerable degree of "cutting in" while Type 347 is unaffected. Types 310 and 316 have considerably less heat effect than Type 302. The affected area was approximately $^{1}/_{16}$ to $^{3}/_{32}$ in. wide and a mean distance of $^{3}/_{32}$ in. from the cut dege.

The powder-cut edges were then welded manually by the metal arc process and mechanically by the submerged melt welding process. Welds were also made in plates that had been beveled by machining on a planer. Specimens from these welds were used as a basis of comparison. The results of the corrosion tests of unstabilized types of stainless steels indicated that for all practical purposes the heat effect on the powder-cut and welded edges and the machined and welded edges were identical. Figure 4 shows representative results on unstabilized Type 304. As a matter of fact some of the machined and welded edges showed greater corrosion than the powder-cut and welded edges, which can be attributed to variation in welding technique. The powder-cut and welded Type 347 were unaffected as shown in Fig. 5. This is a positive indication that the heat effect of powder cutting and

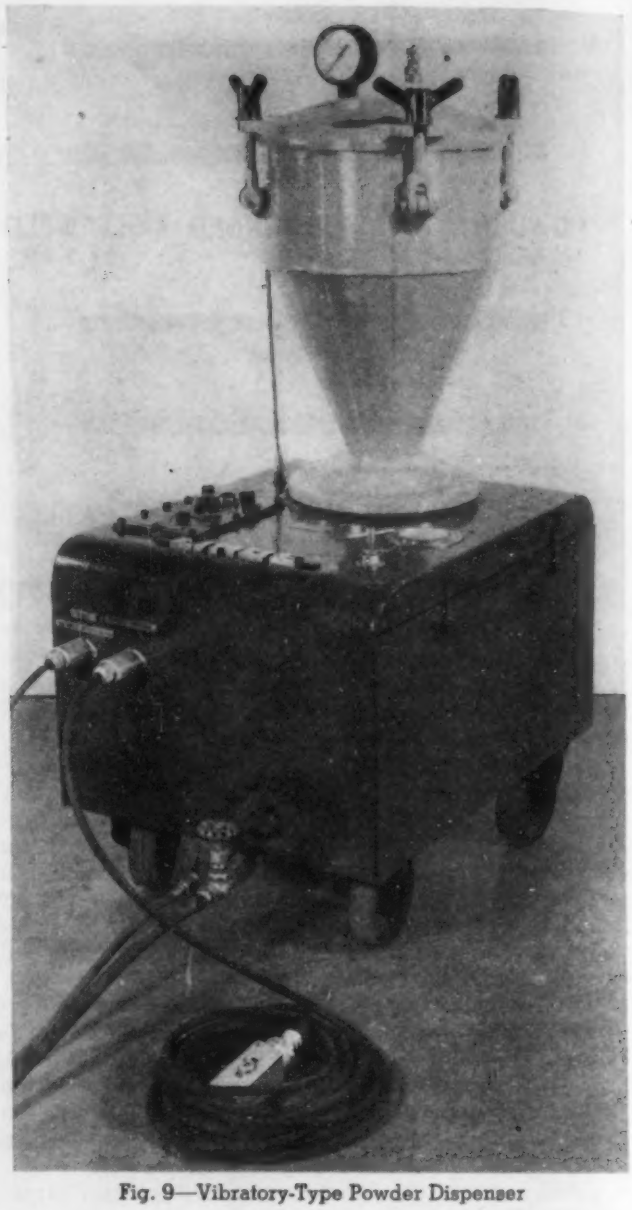


Fig. 9—Vibratory-Type Powder Dispenser

Fig. 10—Front View of Powder-Cutting Attachment for Machine-Cutting Blowpipe

Fig. 11—Stainless Steel Tube Sheet Powder Cut from 4-In. Thick Plate

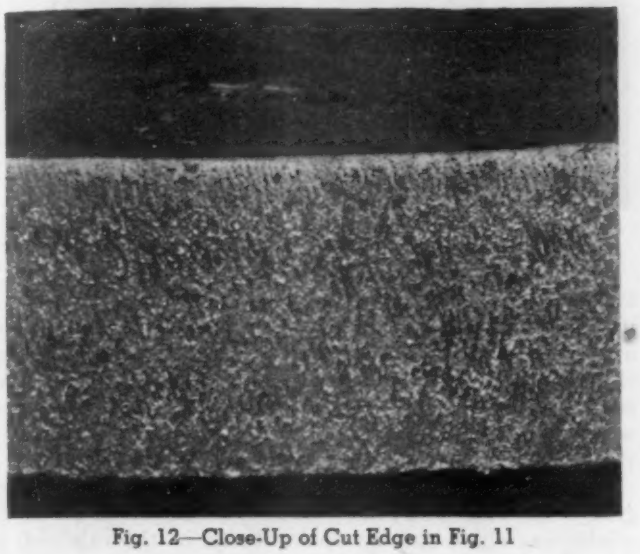


Fig. 12—Close-Up of Cut Edge in Fig. 11

welding is not additive and that the heat-affected zone that shows reduced corrosion resistance following powder cutting and welding, is the same as that produced by the heat of the welding operation alone. Figure 6 shows a comparison of a powder-cut bevel specimen and a powder-cut and welded specimen on Type 310 stainless steel. It will be noted that the corrosion resulting from the welding is much more severe than that from the powder cutting alone. The welds in this case were made without quenching during welding although during manual arc welding the plates were cooled to 212° F. between passes.

Both powder-cut and powder-cut and welded specimens were given a postannealing treatment. In all cases the heat effect was eliminated by this treatment.

Minimizing Heat Effect

While these tests showed that powder cutting was cause for no more concern than unquenched welding techniques, it was believed desirable to go further and investigate ways and means of eliminating or minimizing the heat effect particularly for those edges not to be subsequently welded. This meant decreasing the time interval in the critical-temperature range. A technique similar to that used in high-quality stainless steel fabrication that involves progressively quenching the weld with water was tried in an effort to reduce the heat effect from the cutting operation. The results achieved were promising.

Preliminary tests were first made on $^1/_2$-in. thick Type 304 to determine the combined effect of cutting speed and volume of quenching water. If the speed is too low, water quenching is ineffective in eliminating the heat-affected zone even with water flows as high as 64 gal. per hour. However, with the speed of 20 in. per minute, the water flow was reduced to as low as 21 gal. per hour with almost complete elimination of the heat-affected zone on the $^1/_2$-in. material. Considering these results a water flow of 25 gal. per hour was standardized on four subsequent tests on thicknesses of $^1/_4$, $^1/_2$, $^3/_4$ and 1 in. on Types 302 and 304.

Various methods of applying the water to the plate were tried. One of the simplest and most effective was the use of two low-velocity streams on either side of the nozzle issuing approximately parallel to the plate at about $^1/_4$-in. clearance, and converging on the already formed kerf about 1 in. behind the nozzle. High-velocity water streams caused interference with the cutting action as did complete immersion. A small barrier or dam parallel to and on each side of the line of cut was found to be helpful in confining the water to the quench zone.

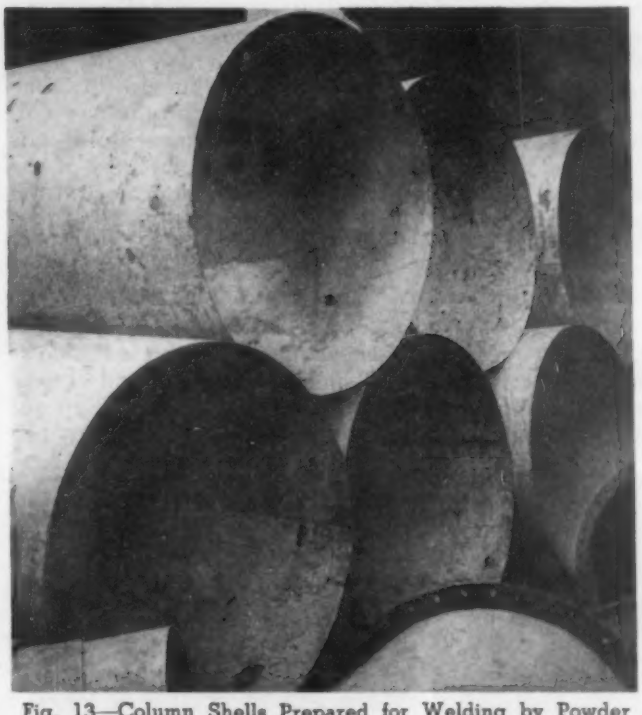


Fig. 13—Column Shells Prepared for Welding by Powder Cutting

Fig. 14—Complete Assembly of Column Section

The results of these tests on the two adjacent cut edges of 1/4-in. thick Type 302 stainless steel are shown in Fig. 7. On the 1/4- and 1/2-in. thicknesses the treatment eliminated the visual indications of loss of corrosion resistance, as compared with the unquenched sample. On the 3/4- and 1-in. thicknesses, as might be expected, the heat-affected zone was still apparent, although to a reduced extent. It can be inferred that this type of quenching treatment will become even less effective as the thickness increases because of the difficulty in getting the cooling water into the kerf.

With those specimens that showed complete removal of the heat-affected zone in the edge cross section, there was in some cases a slight heat-affected zone on the top and bottom surfaces, due to the build-up of fused powder on the top edge and the adherence of slag to the bottom edge. This heat-affected zone was too thin to be observed in the cross section.

This test work has proved that, with regard to carbide precipitation in unstabilized materials, powder cutting as a production tool presents a less serious problem than welding. Furthermore, on sections less than 1/2 in. thick, progressive quenching of the cut will eliminate the zone of carbide precipitation. An incidental discovery in these tests was that the use of a water quench also aids in the removal of scale from the cut edge because of the differential contraction set up between the scale and the base metal.

Powder-Cutting Equipment

The heart of the powder-cutting operation is the powder dispenser, which must provide an even and closely controlled volume of powder to the reaction zone to obtain quality cuts. For general-purpose work pneumatic-type dispensers have been used. These involve no moving parts and operate entirely on a flow of compressed air or nitrogen. For convenience, they are made in two sizes, one of 200-lb. capacity for stationary service, and a small, portable one of 25-lb. capacity suited to shops where work is of an intermittent or maintenance nature. Both these dispensers are shown in Fig. 8.

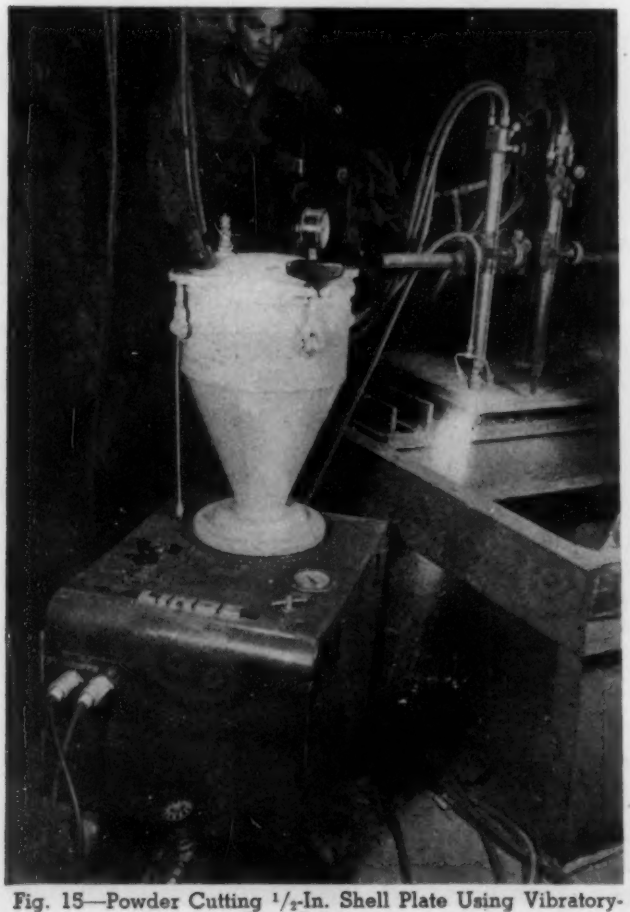


Fig. 15—Powder Cutting 1/2-In. Shell Plate Using Vibratory-Type Dispenser

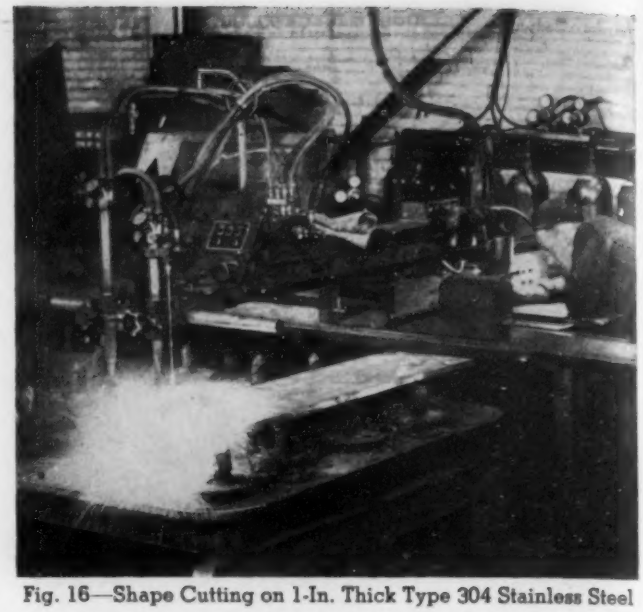


Fig. 16—Shape Cutting on 1-In. Thick Type 304 Stainless Steel

A recent development to provide a more accurate degree of powder flow, such as is often required for high-quality machine-cutting encountered in the fabricating field, is the vibratory-type dispenser shown in Fig. 9. The hopper has a capacity of 100 lb. of powder sufficient for approximately 6 hours of continuous operation at the powder flows used for plate cutting. The powder flow is governed by an electrical vibratory-type feeder. The powder flow is a function of the amplitude of vibration, which is controlled through a manually operated rheostat. A voltage stabilizer is included in the electrical control system to even out any variations in line voltage caused by heavy power loads in a plant.

The air flow is completely independent of the powder flow and thereby enables the best setting of each. The air flow is controlled by a critical flow orifice and is dried as the air passes through a silica gel cartridge.

The powder flow is turned on and off by means of the remote-control switch, which can be placed on the cutting machine or by the line switch on the dispenser itself. The air flow is left on between subsequent cuts and serves to keep the powder lines and cutting attachment clear between cuts.

For machine cutting, standard oxyacetylene blowpipes and nozzles are used, the powder being introduced through a powder attachment that surrounds the nozzle, as shown in Fig. 10. Both nozzle and attachment are held concentrically in the blowpipe head by the same nozzle nut. The powder is preheated to its ignition temperature by passing through the preheat flame. It then mixes with the cutting-oxygen stream approximately 5/8 in. below the end of the nozzle where it burns vigorously.

For hand cutting the powder-cutting attachment can be adapted to the conventional hand-cutting blowpipe or standard powder-cutting blowpipes can be used. The latter are similar to the oxyacetylene hand blowpipes except that the powder valves and passageways are built in as an integral part of the blowpipe. Operators familiar with oxyacetylene cutting can be trained in powder-cutting techniques in a matter of hours. The chief differ-

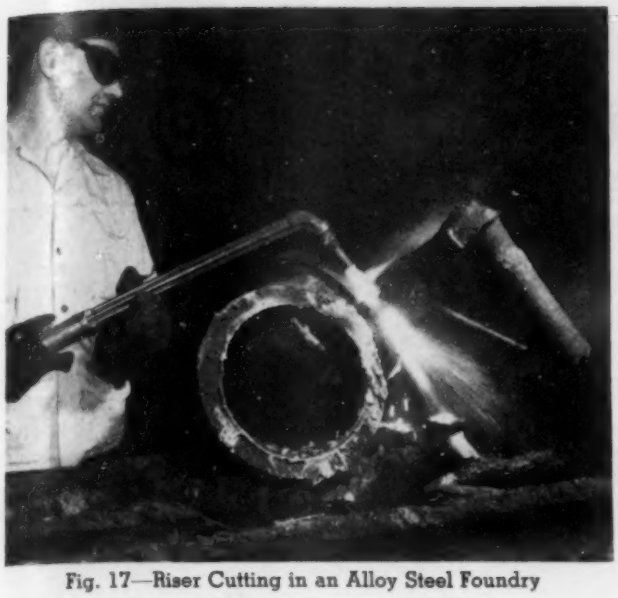


Fig. 17—Riser Cutting in an Alloy Steel Foundry

Fig. 18—Cutting 16-In. Thick Stainless Steel Bloomdown. Slab with Corner Beveled by Powder Cutting to Remove Bad Cracks in Foreground

ences are that with powder the nozzle is carried 1 to $1^1/_2$ in. above the work. Also flying starts are made on all thicknesses.

This equipment meets production requirements at costs considerably less than mechanical means for accomplishing the same purpose.

Typical Production Applications

This review shows that powder cutting meets the basic factors of cost, process effect and equipment required of a production tool. The following are a few representative examples of the work being done in the fabricating industry.

Shown in Fig. 11 is one of five stainless steel tube sheets 4 in. thick and 40 in. in diameter. They were powder cut at a savings to the plant of 16 hr. each compared with the previous method. The powder-cut blank was subsequently turned to finish size on a boring mill. The quality of the powder-cut surface is shown in Fig. 12. Stainless steel powder cuts characteristically exhibit a pebbly finish not encountered on carbon steel. This may be attributed to selective oxidation of the various alloying elements.

Figure 13 shows a stack of stainless steel shells that were powder cut to size for welding on the longitudinal seam. The material thickness on these shells was $^1/_4$ in. Figure 14 shows the complete assembly of a column section incorporating one of the powder-cut and welded shells. All four openings were also powder cut.

Figure 15 shows the powder-cutting process with a vibratory-type dispenser in operation in the same large Midwestern fabricating shop, from which the previous examples were taken. The operator is preparing the edges on a $^1/_2$-in. thick Type 316 plate which is later to be rolled into a shell. This is an all-purpose setup with one blowpipe equipped for powder cutting while the other blowpipe, not in use, is for carbon-steel work.

Figure 16 shows the shape cutting of 1-in. thick Type 304 plates at 14 in. per minute with a No. 6 nozzle operating at 40 lb. per square inch.

While this paper emphasizes the application of powder cutting in the fabricating industry the process also finds extensive use in the steel mill and foundry. Figure 17 shows a typical application for hand cutting of risers in a stainless steel foundry. One large steel foundry is currently powder cutting 44-in. thick risers from stainless steel castings on a production basis. Figure 18 shows a routine stainless steel bloomed-ingot-cutting operation in a steel mill yard on material approximately 16 in. thick. In the foreground is a slab on which the corners have been beveled by powder cutting to remove bad cracks.

It will be apparent from the foregoing discussion of costs that the powder-cutting process offers the same opportunities for production economies in the fabricating shop as it does to the steel mill and other large oxygen users. Its use as a production tool has become firmly entrenched since it allows the fabrication of stainless steel and similar difficult-to-cut materials with approximately the same facility as carbon steel is being fabricated with the oxyacetylene process.

Oxyacetylene Production Cutting in Steel Mills*

By A. H. Yoch and W. Begerow†

THE purpose of this paper is to point out the advantages of mechanized oxyacetylene cutting in steel mill production operations, reviewing briefly cold cutting, billet nicking and revealing new advances in hot cutting both in the process and in engineering which make possible faster cutting with less skill.

The oxyacetylene torch is an old and familiar tool in the steel mill, having made its debut shortly after the turn of the century. Its usage has grown steadily through the years. Remarkable expansion in flame cutting operations is being made in this postwar period, chiefly because of engineering advances coupled with research and development work, brought about because of industrial requirements.

Thousands of torch cuts have been made and are continuing to be made in the laboratory under exacting and controlled conditions with the result that some new cutting techniques have been developed. Considerable data relating to cutting speeds, cutting oxygen flow and preheat requirements for various thicknesses of metal have been compiled. This experimental work has paved the way to improved torch, tip design and operating technique.

It was during the World War II period that the imagination of steel mill production engineers was taxed by the necessity of producing ingots, blooms and billets in cross sections beyond the capacity of shears and saws at hand. In such cases, flame cutting was the only salvation.

Production cutting in steel mills falls in two categories, cold cutting or hot cutting.

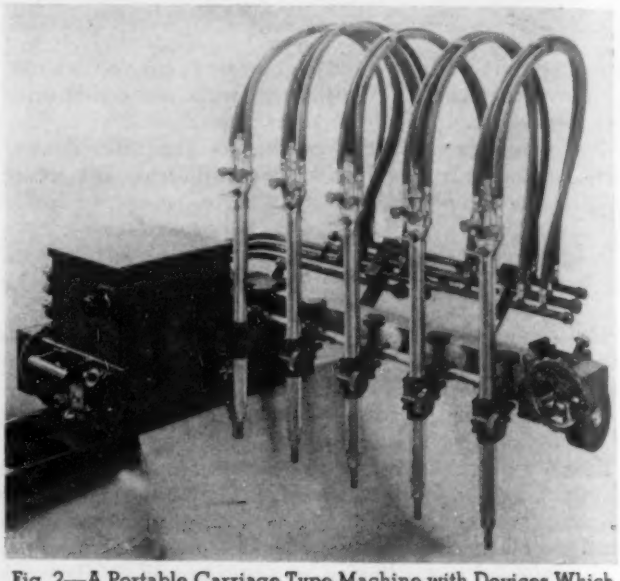


Fig. 2—A Portable Carriage Type Machine with Devices Which Give the Operator Finger-tip Control

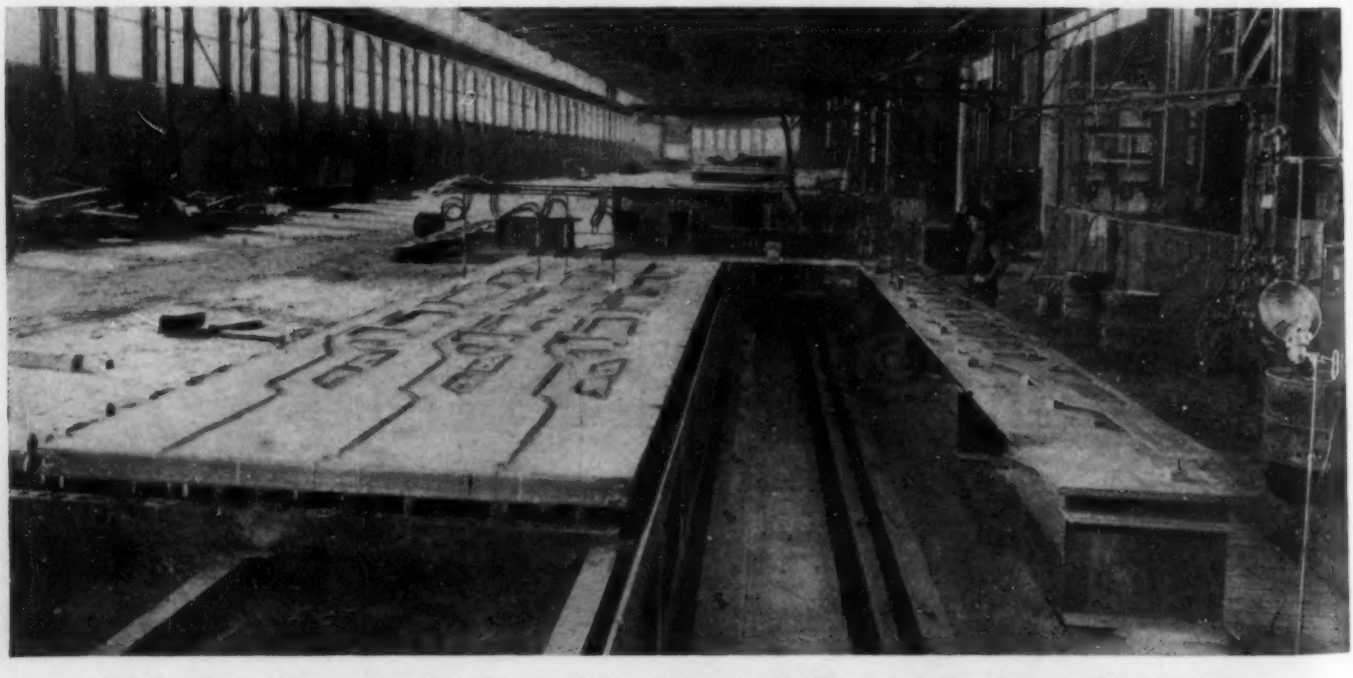


Fig. 1—Three Locomotive Side Frames Being Shaped Simultaneously by Multiple Torch Cutting

* Presented at Twenty-Eighth Annual Meeting, A.W.S., Chicago, Ill., week of Oct. 19, 1947.

† Air Reduction Sales Co., New York 17, N. Y.

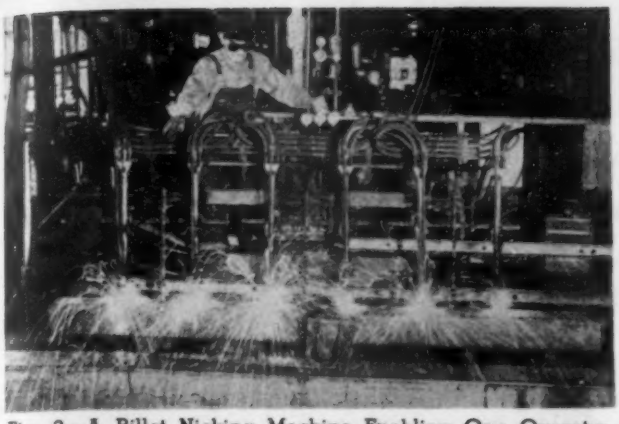


Fig. 3—A Billet Nicking Machine Enabling One Operator to Control Six Water-cooled Torches

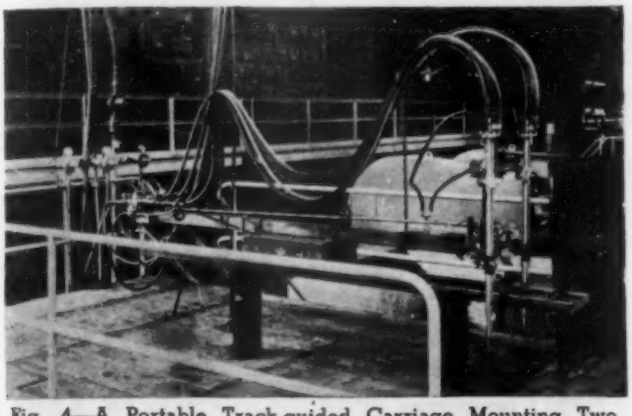


Fig. 4—A Portable Track-guided Carriage Mounting Two Heavy-Duty Torches for Cutting 15-In. Rounds on a Mill Roll Line

Cold Cutting

By cold cutting is meant flame cutting at approximately room temperatures. Cold cutting is a familiar sight and any one of the following operations may be seen on a production basis.

1. Shape cutting from heavy plates, slabs and forgings.
2. Cutting of rounds, squares, flats and billets to length from the stockpile.
3. Cutting or slitting slabs and plates into bars or flats.
4. Nicking blooms, billets and bars from the stockpile.

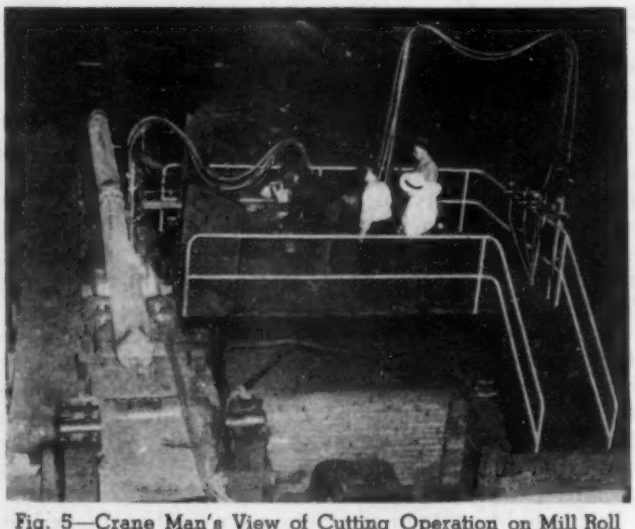


Fig. 5—Crane Man's View of Cutting Operation on Mill Roll Line (see Fig. 4)

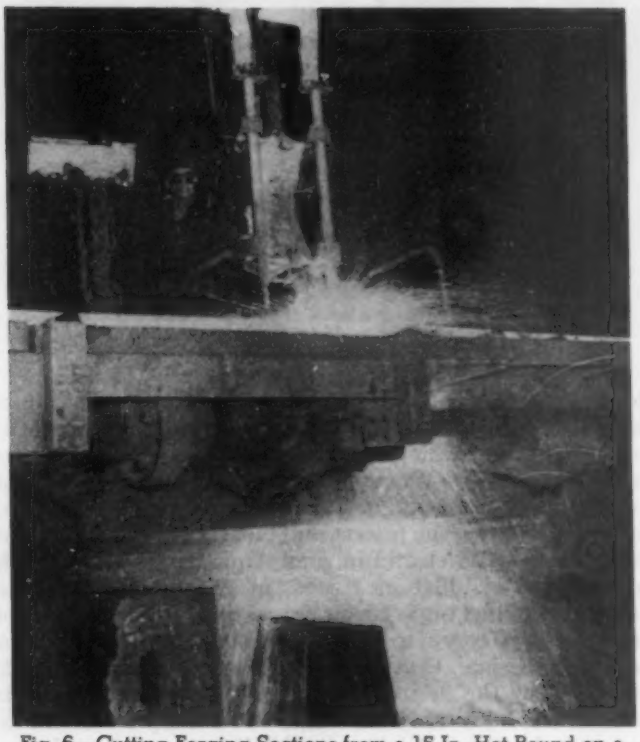


Fig. 6—Cutting Forging Sections from a 15-In. Hot Round on a Steel Mill Roll Line

Cutting of shapes such as locomotive frames, crankshafts, large marine parts from heavyplate, slabs or forgings is now a familiar sight and is no longer considered as a plant or shop achievement. As a matter of fact, as has been mentioned and illustrated in earlier papers, much of this work is now being done with the use of multiple torches. Great economy is effected in production cutting of relatively large shapes prior to subsequent forging or machining operations.

Some steel mills have been able to meet a production severance problem by means of oxyacetylene torches when the cross section at hand was beyond the capacity of existing saws in the mill.

At times steel mills are required to produce billets of various sizes from slabs. Slab slitting is an operation which has been reduced to standard practice in a number of mills. A multiple torch arrangement which provides

Fig. 7—A Quality Cut on a 15-In. Round Made in About 78 Seconds

Fig. 8—Four Sections Cut in the Roll Line from a 15-In. Hot Round

for making a number of simultaneous longitudinal cuts lends itself admirably for this type of production. Another operation which may be considered as cold cutting is billet nicking. When confronted with the problem of producing billets of suitable metallurgical quality to specified lengths, the fastest and most economical method is to nick the billet and in a subsequent operation break off the nicked billet in a press or drop hammer. The technique of nicking is to cut across one of the faces of the billet with a torch to a controlled depth, producing a severe stress line, thus making it possible to easily break the billet at the desired length. The nicking operation lends itself admirably to the use of multiple torches in mass production. Nicking cold billets is a fast and economical severance operation. Millions of slugs for shells were produced by this method during the war.

Hot Cutting

For the purpose of this discussion and steel mill production, by hot cutting is meant flame cutting at elevated temperatures usually in excess of 1500° F. It is in this field that hot cutting offers the greatest opportunity for expansion in steel mill production.

Let us examine some of the reasons why flame cutting is considered in the place of shears or hot saws.

1. Low initial investment.
2. Low maintenance cost.
3. Negligible power requirements.
4. No deformation of material, as is experienced by the use of shears.

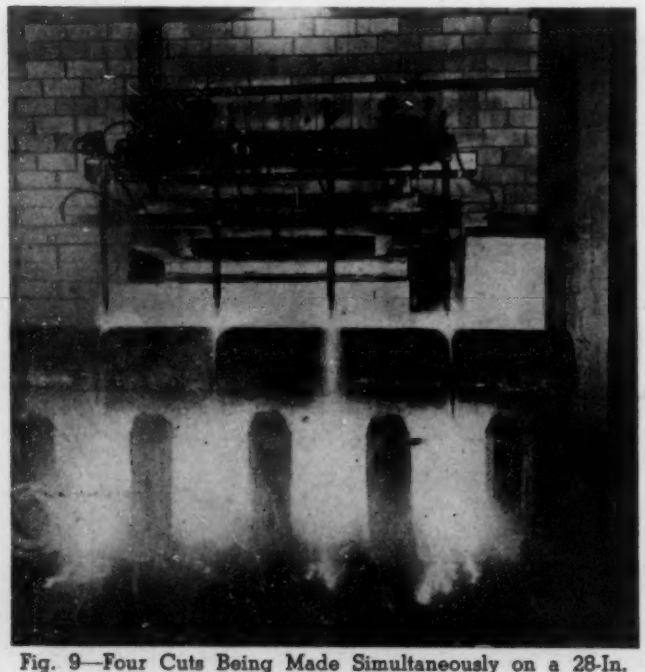


Fig. 9—Four Cuts Being Made Simultaneously on a 28-In. Diameter Alloy Forging

5. Ability to cut heavy thicknesses.
6. Ability to make rapid and multiple cuts.
7. Ability to make contour cuts.

Cutting at elevated temperatures requires no special consideration form a metallurgical standpoint.

In general the speed of cutting is from $2^1/_2$ to 3 times faster than cold cutting depending on the thickness being cut.

In hot cutting operations we are concerned with two types of cuts:

1. Quality cut.
2. Severance cut.

A quality cut is one which has a straight and smooth surface with little or no deviation from the perpendicular. A quality hot cut compares favorably to a quality cut

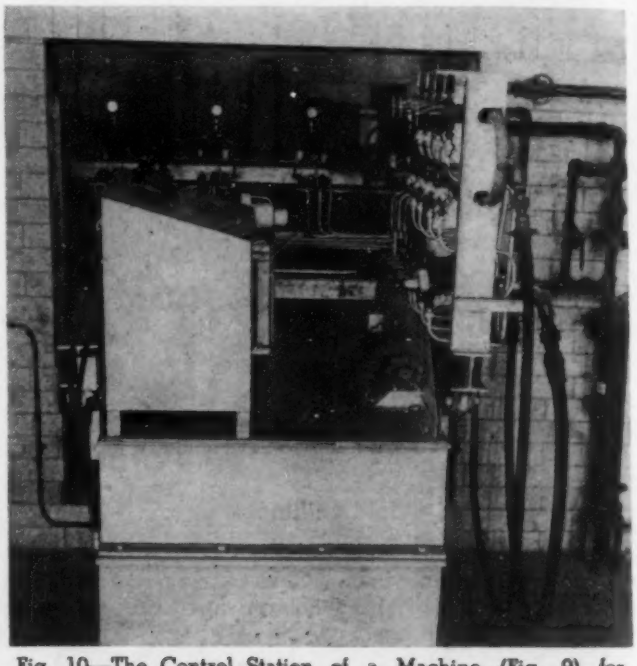


Fig. 10—The Control Station of a Machine (Fig. 9) for Making Four Simultaneous Cuts on a 28-In. Diameter Alloy Forging

made on cold material. Quality cuts are required when the cut piece must be held to close a dimensional or weight tolerance. This is usually necessary when the cut pieces are to be subjected to press forge operations.

Severance cuts are primarily drop cuts in which dimensions and surface condition are disregarded.

Severance cuts are usually applied to cropping operations and as might be supposed can be made at faster rates of cutting speed than quality cuts.

Improvement in both process and equipment design have made possible the development of the flying start technique in hot cutting operations. By the flying start is meant the ability to start the cut with the torch in motion as it approaches the material to be cut, this eliminating the exacting and time consuming positioning of the torch in relation to the starting face at the start of the cut.

The need of particular skill to perform hot cutting operations is no longer required. Only a few years ago cutting of hot blooms or relatively large diameter rounds would be considered an operation requiring the services of a specialist. Improvments in cutting machine designs and operating technique eliminates the need of specially trained and experienced operators.

Even quality cuts in production are easily achieved by adhering to proper cutting speed, cutting oxygen flow

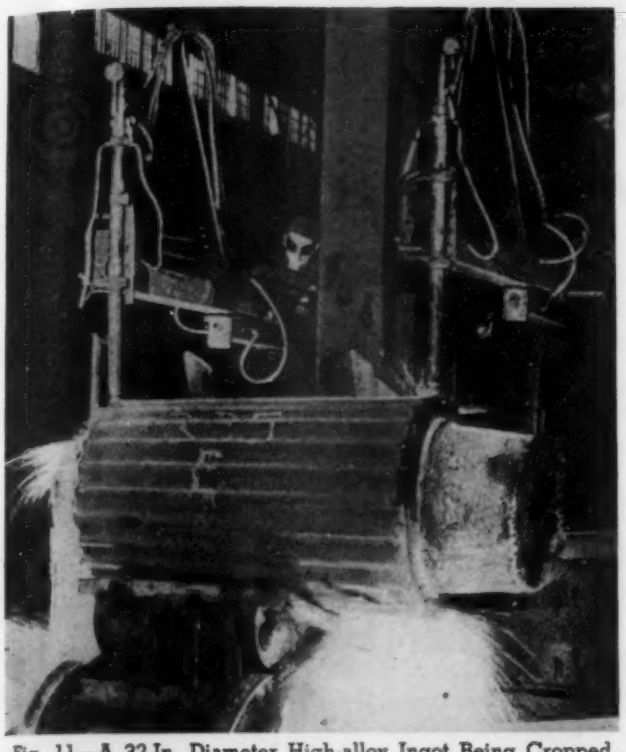


Fig. 11—A 32-In. Diameter High-alloy Ingot Being Cropped at Both Ends Simultaneously

and preheat for any particular cross section at hand. It might be well to mention at this point that in a large quantity of 15-in. diam. sections, each section, which weighed over 600 lb., was held within a weight tolerance of minus zero plus 5 lb.

Usually in cutting ingots or forgings, the material is heated in a furnace prior to the cutting operation and is usually positioned in front of the cutting machine by placing it in a cradle or car specifically designed to receive the piece. With blooms and billets, however, the cutting operation is usually performed in the roll line immediately following the rolling operation and within the roll mill cycle.

The flame cutting machine of today is a unit in keeping with steel mill design adequately water-cooled and shielded to protect the machine from the heat of the bloom and the cutting operation. It is operated by remote control by means of master switches on a control desk which is usually located in a pulpit. Operation of master switches is all that is required of the operator. The gases for the cutting operation are controlled by means of solenoid valves actuated by master switches. The pressure of the gases may also be remotely adjusted from the control desk. A tachometer is usually provided at the control desk to give visual indication of the cutting speeds.

The torch may be raised, lowered, or angled by remote control. Machines when cutting in the roll line are designed to give rapid retraction or quick return of the torch to minimize the time required to make ready for the following cut.

Figure 1 shows a multiple torch shape cutting operation. Three locomotive side frames are being cut simultaneously from a slab $5^1/_2$ in. in thickness. Photo courtesy of Lukens Steel Co.

In Fig. 2 is shown a portable carriage type machine designed for slab slitting or slab ripping operations. The gases to the torches are fed from a manifold, and are controlled by means of solenoid valves actuated by a drum type switch giving the operator finger tip control.

Figure 3 shows a billet nicking operation. This machine is equipped with six cutting torches, and six nicks or shallow cuts are being made across the top face of the bloom simultaneously.

A close up of a cutting machine arrangement for cutting of a hot 15-in. diam. round using a dual or multiple torch arrangement for cutting a section from a bloom for the forging of a disk is shown in Fig. 4. The torches are raised and lowered over the round by means of a motor driven by remote control. The preheat and cutting gases are manually controlled by lever operated valves. The water cooled torches and the gas control valves are attached to a water-cooled square tubular bar which is mounted on a carriage type cutting machine.

Figure 5 shows a crane man's view of the cutting station equipment, roll line and material being cut.

Figure 6 is another view of cutting of a forging section from a 15-in. diam. hot round bloom. This cut section weighed 685 lb. with a weight tolerance of minus zero plus 15 lb. maximum. A great number of sections were cut for experimental forgings and the average deviation on weights was held within 5 lb.

Figure 7 is a view of quality cut on a 15-in. diam. round made at an average speed of 11 in. per min. or approx. 78 sec. duration for the cuts.

The cutting oxygen flow rates are approximately 2000 cu. ft. per hour and preheat acetylene approximately 100 cu. ft. per hour.

Where quality of cut is not required and speed of cutting is needed to meet mill cycles the severance cut can be made in approximately 45 sec. using a cutting oxygen flow of approximately 2800 cu. ft. per hour and approximately 250 cu. ft. of actylene per hour. (See Fig. 8)

Figure 9 shows four cuts being made simultaneously on a 28-in. diam. alloy forging. This forging is placed on a car in front of the heating furnace and is rolled into position in front of the cutting machine. The entire operation of machine and gases is by remote control.

Figure 10 shows the control desk from which the operator controls the machine, and preheat and cutting gases.

Figure 11 shows a 32-in. diam. high alloy ingot being cropped at both ends simultaneously. These ingots are first heated in a furnace and set in a V-support which au-

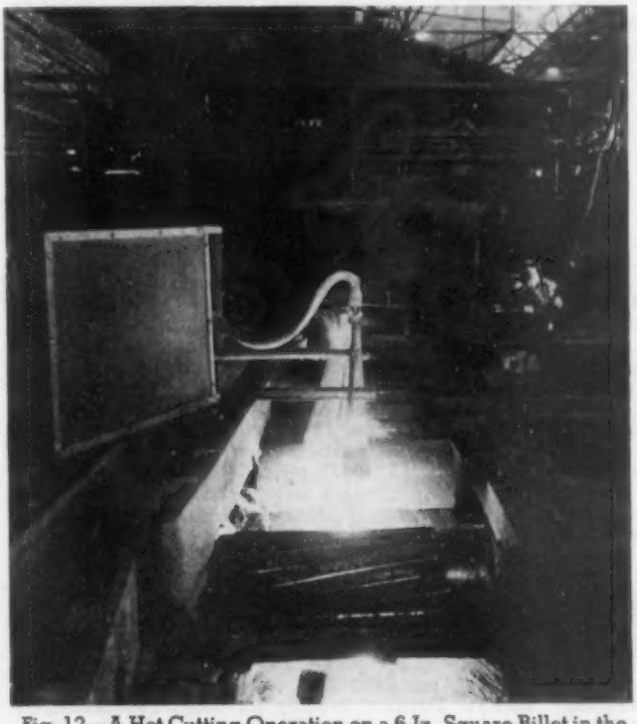


Fig. 12—A Hot Cutting Operation on a 6-In. Square Billet in the Roll Line

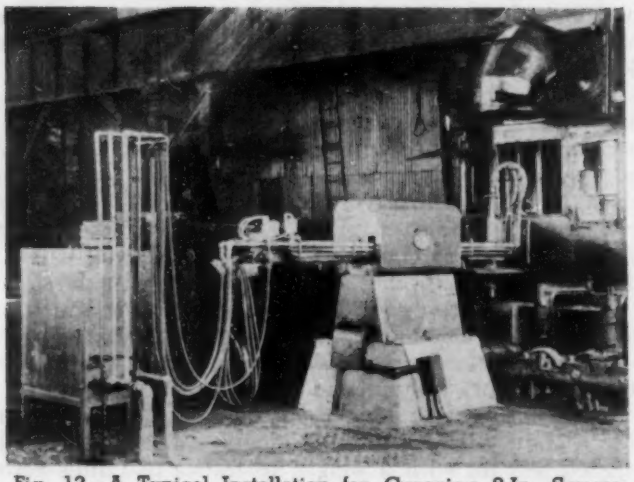


Fig. 13—A Typical Installation for Cropping 8-In. Square Blooms

tomatically positions it for the cutting operation. Production is approximately 4 ingots per hour.

Figure 12 shows a hot cutting operation on a 6-in. square billet in the roll line. The billet was cut in desired lengths within the roll mill cycle. The time per cut is approximately 18 sec.

Figure 13 is a typical installation of a cutting machine for cropping the ends of 8-in. square blooms.

As can be observed, this machine is adequately protected from the heat of the bloom and the cutting operation. It is also shielded from the particles in the atmosphere. The torch and machine members in proximity of the heat of the blooms are water cooled. Solenoid valves used to control the gases can be seen at the rear end of the tubular ram.

Within the cabinet is housed the gas regulating equipment.

These 8-in. square blooms are cut at a speed of approximately 30 in. per minute. A 40-ft. bloom is cut at the leading end, moved ahead by the roll table and cut at the trailing end in a period of 45 sec.

Figure 14 is a picture of the control desk for the hot cutting machine All movements of the torch—horizontal, vertical and angular—and the speed of cutting and control of the preheat and cutting gases are controlled

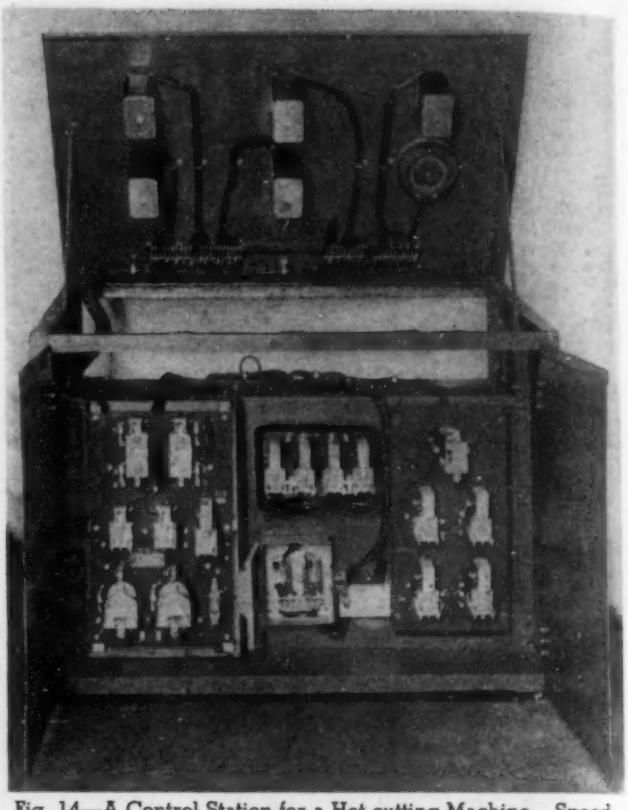


Fig. 14—A Control Station for a Hot-cutting Machine. Speed, Gas Flows, Torch Positioning and Movement Are All Controlled from the Desk

from this desk. It is possible to locate the desk at any desirable location independent of the machine. All joints are gasketed to protect the electrical contacts and terminals from dirt and conductive materials in the surrounding atmosphere.

Summation

With elimination of skill, improved technique and engineering advances in equipment, there is a definite trend in steel mills to use the mechanized oxyacetylene cutting in production operations.

Current Welding Literature

Accident Prevention. Accidents in Electric Arc Welding and Their Prevention, R. Schmelz. Assn. Engrs. & Architects in Palestine—J., vol. 8, no. 3 (June 1947), pp. 6–10.

Alloys, Heat Resisting. Welding Characteristics of High Temperature Alloys, C. G. Chisholm. Steel, vol. 121, no. 26 (Dec. 29, 1947), pp. 54–56, 58, 60.

Barrels, Steel. Two Million Monthly—Steel-Barrel Industry. Petroleum Refiner, vol. 26, no. 11 (Nov. 1947), p. 767.

Boiler Manufacture. Automatic Fusion Welding. Elec. Rev., vol. 141, no. 3638 (Aug. 15, 1947), pp. 237–242.

Brazing, Electric. Advantages and Applications of Controlled Atmosphere Copper Brazing, F. Humberger. Industry & Welding, vol. 20, no. 12 (Dec. 1947), pp. 26–29, 58–61.

Brazing. Art of Brazing, H. R. Brooker. Machy. Market, no. 2448 (Oct. 17, 1947), pp. 451–452; no. 2449 (Oct. 24), pp. 465–467; no. 2450 (Oct. 31), pp. 476, 480.

Brazing. Brief Review of Brazing Processes, H. R. Brooker. Sheet Metal Industries, vol. 24, no. 246 (Oct. 1947), pp. 2041–2045; no. 247 (Nov.), pp. 2253–2256 (Dec.), pp. 2457–2462; no. 248 (discussion), pp. 2462–2466.

Brazing. Electric Furnace Brazing for Mass Production, H. Eickelberg. Iron Age, vol. 160, no. 25 (Dec. 18, 1947), pp. 56–59.

Brazing, Silver Alloy. ABC's of Silver Alloy Brazing, W. J. Van Natten. Iron Age, vol. 161, no. 2 (Jan. 8, 1948), pp. 51–55.

Brazing, Silver Alloy. Production Methods of Low Temperature Silver Alloy Brazing, A. M. Setapen. Steel Processing, vol. 33, no. 12 (Dec. 1947), pp. 761–765.

Car Couplings, Manufacture. Fabricating Rolled Steel Draft Gears for Railroad Cars, E. F. Ross. Steel, vol. 121, no. 26 (Dec. 29, 1947), pp. 46–48.

Car Couplings, Manufacture. Steel Tubing and Plate Replaces Castings in Heavy-Duty Parts, K. Rose. Matls. & Methods, vol. 26, no. 6 (Dec. 1947), pp. 68–70.

Car Couplings, Manufacture. Welded Design Takes Shock. Industry & Welding, vol. 20, no. 12 (Dec. 1947), pp. 40–42, 63–64.

Coal Preparation Plants, Equipment. Welding for Coal Preparation, H. D. Larner. Industry & Welding, vol. 20, no. 11 (Nov. 1947), pp. 26–29, 74–75.

Electric Relays, Manufacture. Tricky Tooling Cuts Relay Costs, P. Bonness. Am. Mach., vol. 92, no. 1 (Jan. 1, 1948), pp. 93–95.

Electric Welding, Arc, Argon. Commercial Applications of Argon-Arc Welding, J. L. Adams. Industry & Welding, vol. 20, no. 12 (Dec. 1947), pp. 36–38.

Electric Welding, Arc. Heliarc Welding for Difficult-to-Weld Metals and Alloys, H. T. Herbst and F. J. Pilia. Product Eng., vol. 19, no. 1 (Jan. 1948), pp. 127–131.

Electric Welding, Arc. Heliarc Welding Magnesium, Stainless, Aluminum at Northrop, H. C. Eubank and T. E. Piper. Industry & Welding, vol. 20, no. 10 (Oct. 1947), pp. 30–32, 34, 78.

Electric Welding, Arc, Heliarc Process. Mechanized Welding of Cylindrical and Spherical Shells, H. T. Herbst. Machy. (N. Y.), vol. 54, no. 5 (Jan. 1948), pp. 164–165.

(*Continued on page 216*)

Adams Lecture for 1947—Structural Strength of the Welded Joint*

By G. S. Mikhalapov†

WELDING today has become so widely and universally accepted and the performance in service of overwhelming majority of welded structures has been so eminently satisfactory that a tendency exists to take for granted the strength of all radiographically sound welded joints.

Because of this tendency I would like to draw the attention of the engineering profession to the fact that under certain conditions of service and stress, the welded joint can be by far the weakest part of a structure.

Many years ago Dr. Comfort Avery Adams first pointed out to me, as well as to many others, that great differences may exist in the type of service stresses to which structures may be subjected, and the danger of the assumption that the behavior of welded structures under all types of service stresses can be predicted on the basis of experience limited to one kind of service. It is perhaps this common assumption that for many years obscured more than anything else the true picture of the part played by the welded joint in the service performance of the parent structure.

During the last war, it was my good fortune to be directly connected with a great deal of welding research sponsored and conducted by government agencies as well as by private industry. Most of this research did not result from long-range planning, but was rather of a shotgun variety; that is, it was directed toward immediate and practical solution of problems which arose as a result of tremendously expanded use of welding, as well as from application of welding to a somewhat different type of structure than the one familiar to us before the War.

In looking back and reviewing the problems which the wartime research attempted to solve, a very definite pattern emerges. Problems, and frequently quite serious problems, arose as soon as welding was applied in a manner different from the practices developed prior to war and thoroughly familiar to the welding industry. It was almost as if a serious misunderstanding or lack of knowledge of the fundamentals underlying welding existed, and as if successful welding before the war were due to practices developed entirely by trial and error and not capable of intelligent extrapolation to a new application.

The majority of problems arose when welding was applied to rigid, relatively massive structures, particularly whenever steels of greater tensile strength and hardenability than the so-called mild steel were used or whenever these structures had to be used at low temperature. The difficulties encountered were twofold. The first encountered during fabrication was that of cracking in or near the welded joint, and the second was inability of the fabricated structure to withstand stresses imposed by the service for which the structure was intended. Although the two are intimately connected, the topic of this discussion has to do primarily with this second phase.

A great deal has been written during and since the War on the subject of true strength and the mechanism of fracture of metals. Reports like the one prepared by Gensamer, Saibel and Ranson[1] go a long way toward clarifying our knowledge, or rather lack of it, of this subject, and point the need and the way to research. Less thought has been given to the subject of the strength of the welded joint, even though evidence exists that at present it plays a greater part in the mechanism of failure of a welded structure than the prime metal. For this reason, I should like to leave with you some thoughts on this subject which I hope may stimulate the carrying out of the great volume of research which is necessary before we can truly say that we know quantitatively what performance to expect from any welded joint in any service.

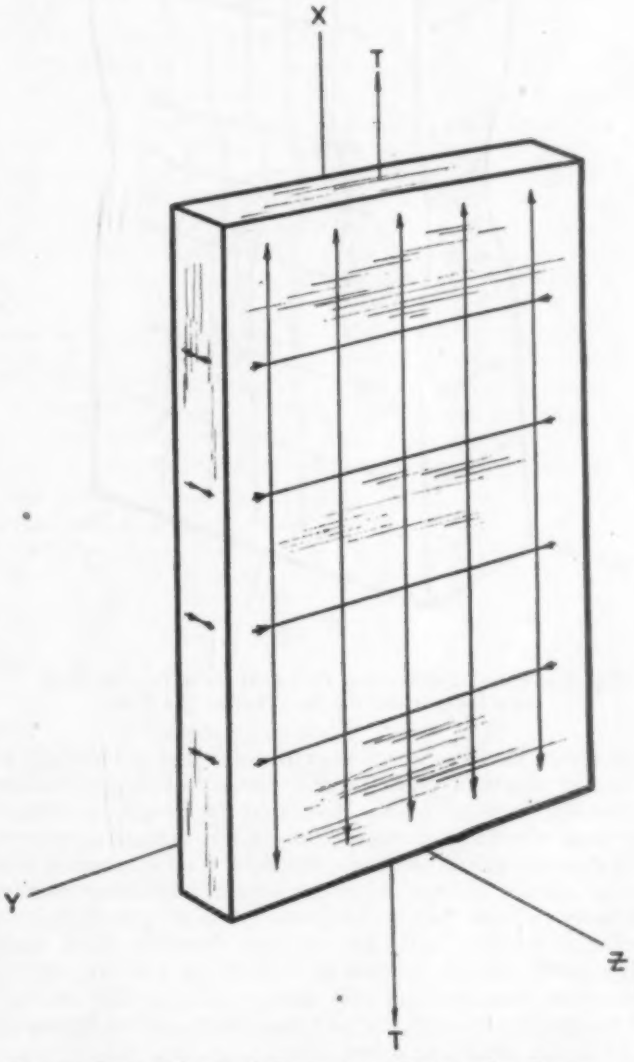


Fig. 1—Typical Lines of Stress in a Rectangular Bar or a Portion of a Plate Subjected to Tension Load *T*

* Presented at 28th Annual Meeting, A.W.S., Week of Oct. 19, 1947, Chicago, Illinois.

† Manager, Apparatus Research Dept., Air Reduction Sales Company, Murray Hill, N. J.

In general, it can be said that the term "strength" when applied to a structure and to its components denotes their ability or rather degree of ability to withstand without failure, stresses and strains imposed on them by the service which the structure is intended to perform. Although this definition is hardly original or novel, I do not believe that many engineers are aware of its full implications in the case of a welded joint. Thus, when a component of a structure, such as a welded joint, has to carry in service a tension load, an average engineer usually thinks in terms of uniaxial tension stress in the joint and would be apt to assume that the performance of the particular joint in tension at any time could be predicted fairly well by the behavior at room temperature, of a very small section of the joint under direct tension load in a tensile testing machine. In general, this concept is reasonably accurate for simple uniform joints possessing little three-dimensional stability and rigidity.

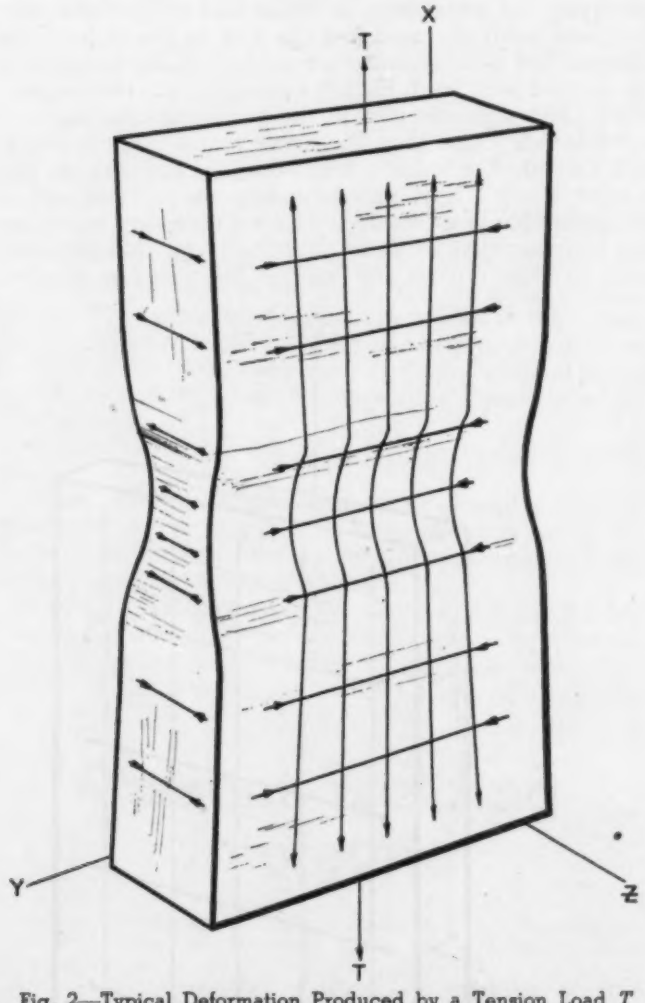


Fig. 2—Typical Deformation Produced by a Tension Load *T* in a Rectangular Bar or a Portion of a Plate

However, it may be quite erroneous and misleading in cases of joints of great three-dimensional rigidity where three-dimensional plastic flow may be greatly inhibited by nonuniformity of stress produced by certain geometrical discontinuities such as notches, reinforcements and other abrupt change in cross section. In other words, although a joint may be subjected to what appears to be a uniaxial tension load, the stresses resulting from such apparently simple tension load may be and frequently are, quite complex and may contain appreciable stresses in the plane normal to the principal stress and of the same sign as the principal stress.

One of the simplest examples of the presence of stress

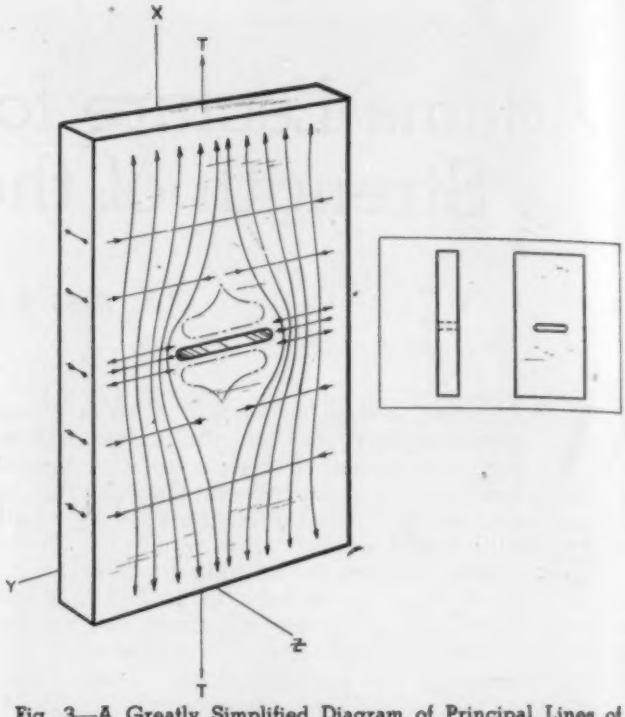


Fig. 3—A Greatly Simplified Diagram of Principal Lines of Stress Produced by a Tension Load *T* in an Internally Notched Rectangular Specimen

components normal to the major stress at a geometrical discontinuity is provided by a simple internal notch. Figure 1 shows a rectangular bar or a portion of a plate subjected to simple tension load along its major or *X* axis. Under the load the bar will elongate in the normal manner along the *X* axis at the expense of its width and thickness or, to use a three-coordinate system, at the expense of its *Y* and *Z* dimensions, as shown on Fig. 2.

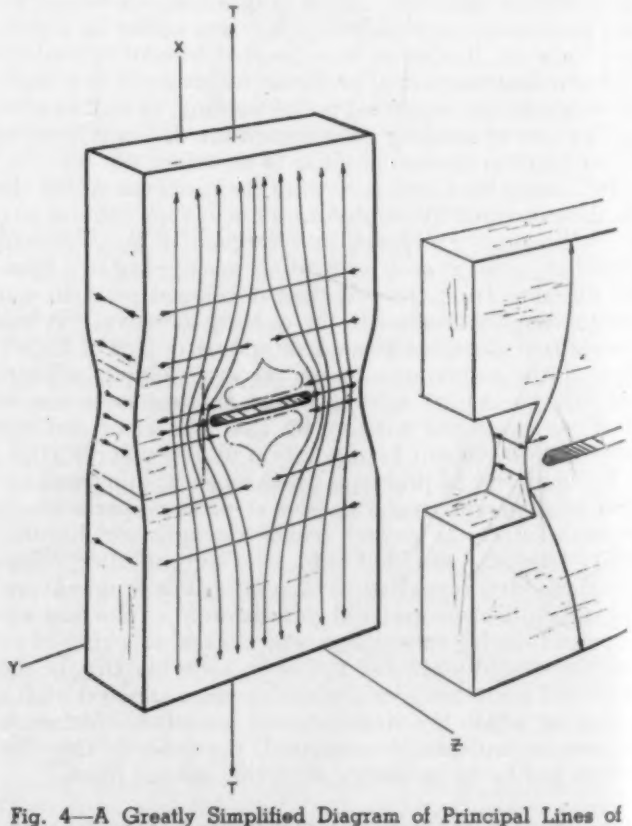


Fig. 4—A Greatly Simplified Diagram of Principal Lines of Stress in an Internally Notched Rectangular Specimen Undergoing Deformation Under Tension Load *T*

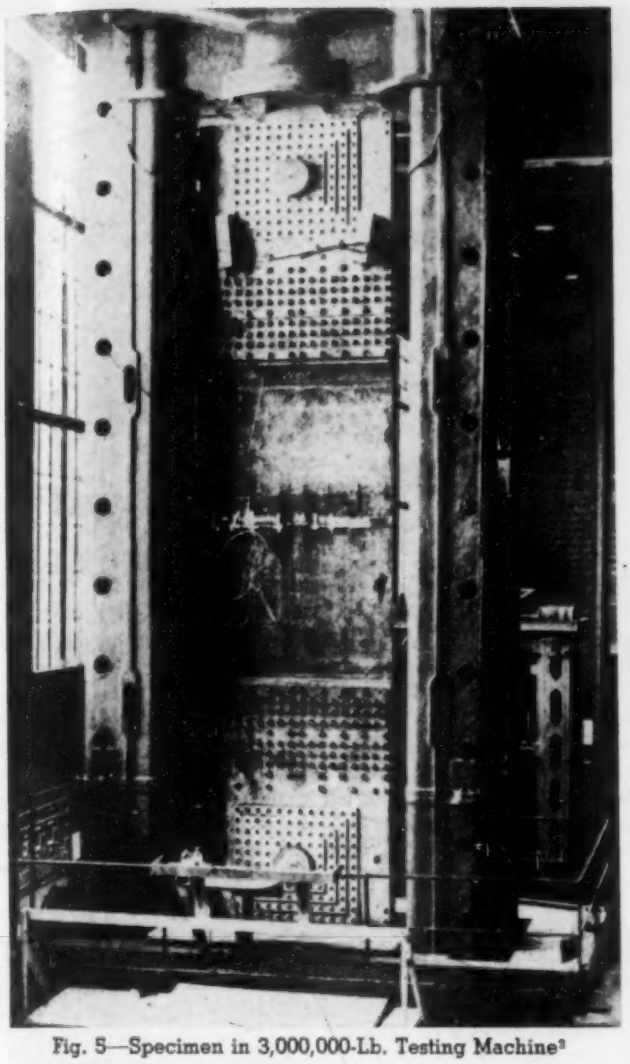


Fig. 5—Specimen in 3,000,000-Lb. Testing Machine[3]

Figures 3 and 4 show a similar bar except for an internal notch normal to the tension load along the X axis. The lines of stress now run around the notch leaving islands of unstressed material both above and below the notch. Since these islands are not stressed along the X axis, they will not tend to deform in the manner of the rest of the specimen, but will resist the deformation in the rest of the specimen. Thus material immediately back and above the notch, or at the boundary of the unstressed islands,

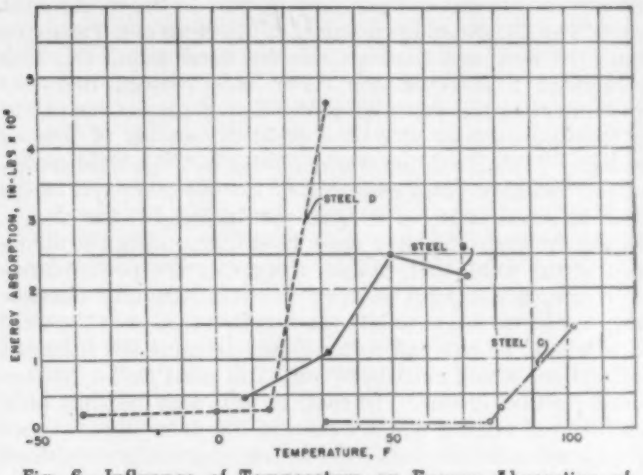


Fig. 6—Influence of Temperature on Energy Absorption of 72-In. Wide Plates[6]

will be prevented from contracting normally along Y and Z axes by the restraining influence of the islands and will be in tension along these axes. Thus a small area immediately back of the notch will be subjected to a high tension stress along the X axis and to a lower tension stress along Y and Z axes.

Although conditions produced by a notch are among the easiest to envisage, they are by no means the only ones which will produce triaxial tension. Actually any condition restraining or restricting three-dimensional plastic flow of any material under tension stress may produce tension stress components normal to the principal stress.

It is reasonable to assume, therefore, that components, particularly joints, of all structures but those of the simplest geometry, are usually required to withstand triaxial stresses and, therefore, knowledge of the behavior of the structure's component materials such as weld metal, parent plate metal, etc., under uniaxial stress is not sufficient to predict performance of the structure under service conditions, except perhaps in a case of a hypothetic material whose resistance to deformation and to fracture is the same under combined stesses as it is under a single stress.

Knowledge of resistance to fracture under combined stresses of both the weld metal and of the parent plate metal which has been physically or chemically affected by the welding processes is therefore imperative if true evaluation of service strength of all welded joints is to be obtained. When one considers the variety of metallurgical

Table 1—Chemical Composition and Tensile Properties of Steels B, C and Dn[3,4,5]

Steel Designation	Chemical Composition, %												
	C	Mn	P	S	Si	Al	Ni	Cu	Cr	Mo	Sn	N_2	O_2
B	0.18	0.73	0.008	0.030	0.07	0.015	0.05	0.07	0.03	0.006	0.012	0.004	0.010
C	0.24	0.48	0.012	0.026	0.05	0.016	0.02	0.03	0.03	0.005	0.003	0.003	0.010
Dn	0.19	0.54	0.011	0.024	0.19	0.019	0.15	0.22	0.12	0.021	0.025	0.006	0.002

For all steels, V <0.02% and As <0.01%

Steel Designation	Tensile Properties			
	Ultimate Strength, Psi.	Yield Point, Psi.	Elongation in 8 In., %	R/A, %
	(0.75-In. Flat Bar Specimen)			
B	57,000	32,300	33.4	67.5
C	66,200	35,600	30.0	53.0
Dn	59,500	34,900	32.4	61.4
			Elongation in 2 In. %	
	(0.505-In. Diam. Specimen)			
B	57,150	33,050	45.7	71.5
C	67,200	37,000	38	57.0
Dn	62,500	37,400	37.0	65.0

Steel B—Semi-killed, as-rolled ship plate. Steel C—Semi-killed, as-rolled ship plate. Steel D—Killed, normalized, $^3/_4$-in. ship plate

structures present in the zone adjacent to the weld metal, as well as the possible chemical effect of an electric arc on both the weld and the heat-affected zone metal, this task is indeed a difficult one. For this reason, much of welding research devoted to studies of properties of the individual components of a welded joint is of limited value. Tests for determining strength of the weld metal, of the fusion or bond zone and of the various parts of the heat-affected zone have been conducted by the dozen. However, useful as they are for understanding the structure of the weld, their ability to predict the performance of a completed joint is very doubtful, usually because they either do not simulate the service stresses in the weld as a whole, or else fail to take into account the inherent differences which exist between a full joint and a synthesized portion of one. In fact, it well may be that only methods of testing which evaluate the over-all resistance of at least a simple butt weld to fracture under combined stresses are of real value and use.

Although we do not know much about resistance to fracture and to deformation of metals under combined stresses, it would appear that the former is considerably higher and the latter lower in thin ($1/2$ in. and under), fine-grained steel plates than in thick, comparatively coarse-grained plates. It would also appear that weld metal and metal immediately adjacent to it are particularly susceptible to fracture under combined stresses. It is perhaps for these reasons that the service record of structures made of comparatively thin plate and relatively flexible joints or joints with low three-dimensional stability and rigidity is generally good and that it is only in structures made of plate over $1/2$ in. thick and of complex and rigid geometry, that service failures begin to occur.

Table 2—72-In. Wide Plate Tensile Data[4]

Test Temp., ° F.	Ultimate Strength (Net Section), Psi.	Total Energy Absorbed at Failure, In.-Lb.	Fracture Type
	Steel B		
8	34,600	455,000	Cleavage
32	38,500	1,100,000	Cleavage
50	40,200	2,495,000	40% shear–60% cleavage
72	40,000	2,200,000	Shear
	Steel C		
31	37,000	119,000	Cleavage
78	37,800	102,000	Cleavage
81	35,700	314,000	Cleavage
102	43,200	1,457,000	Shear
	Steel D		
−38	37,600	249,000	Cleavage
0	38,900	250,000	Cleavage
15	37,400	255,000	Cleavage
32	43,200	4,650,000	Shear

There are in addition several other parameters of service conditions to which structures and welded joints are subjected which became more clearly perceived during the War, or rather which were not generally considered before the War. Those are rapid rate of loading with resulting high rate of strain, steep strain gradient and low

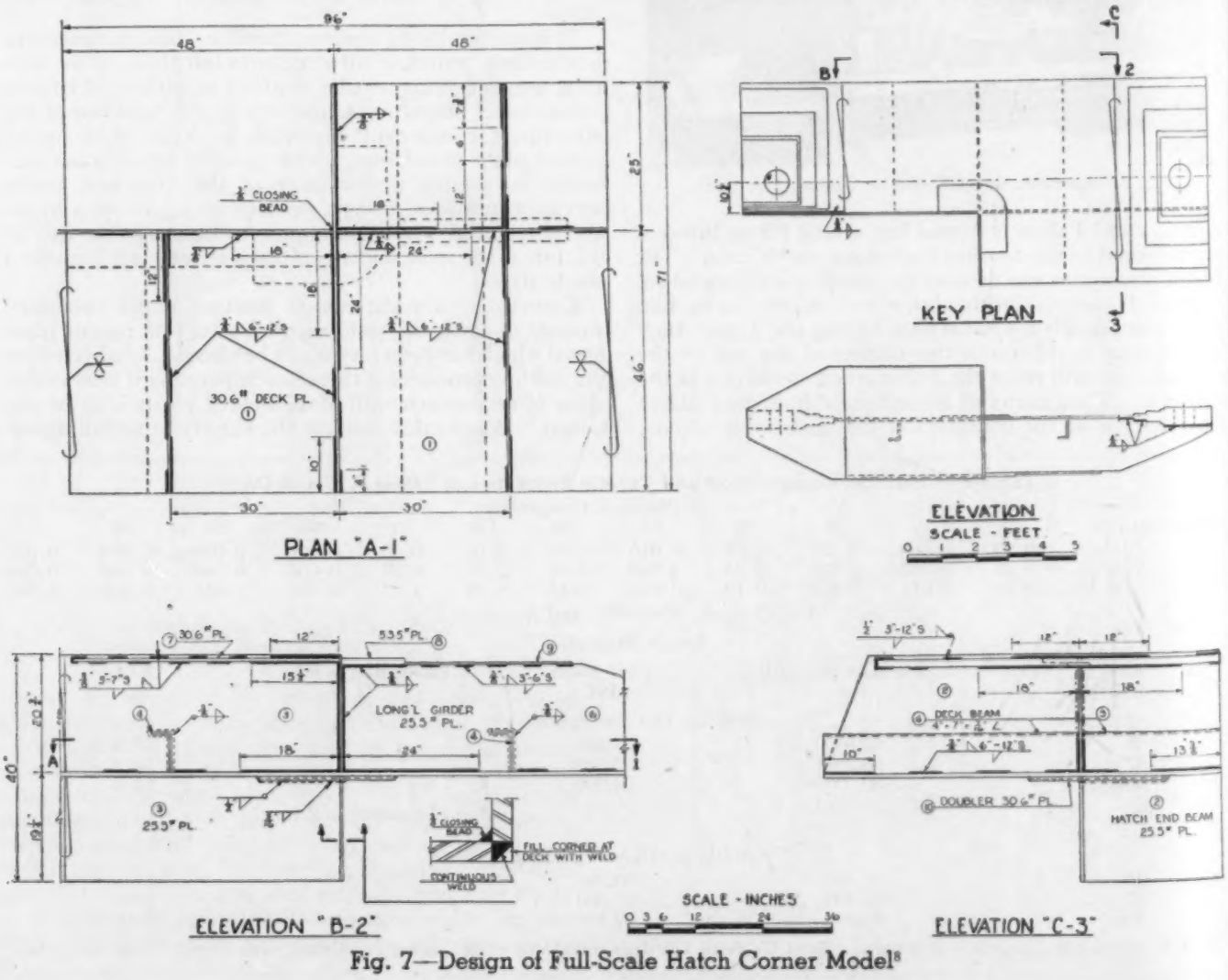


Fig. 7—Design of Full-Scale Hatch Corner Model[8]

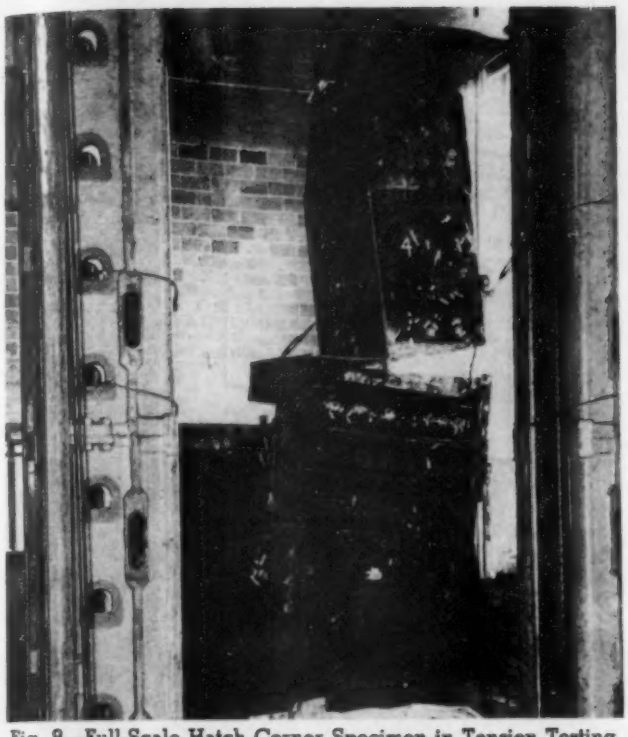


Fig. 8—Full-Scale Hatch Corner Specimen in Tension Testing Machine; View from Above[5]

temperature. Certainly to date, we have not been able to even begin to distinguish between the relative importance of all of these parameters, but it does appear as if to some extent at least, they are interrelated and that the effect of one could be reproduced to a degree by another. Thus low temperatures appear to produce much the same effect on resistance to deformation and resistance to fracture of steels as do rapid rates of strain; and three-dimensional rigidity, particularly at low temperatures, appears to affect service performance of welded joints in the same manner as does triaxial tension combined with high rate of strain.

Since the strength of the welded joint is dependent to such an extent on the strength of the component steel plate, and since our knowledge of the whole subject of behavior of steel under any but the most simple state of stress is admittedly inadequate, what is the factual evidence then that appears to point to the contention that the welded joint is the weaker part of a structure?

I believe an analysis of the results of several pertinent investigations conducted in the last few years will reveal substantial evidence that under many service conditions, performance of a welded joint made in accordance with the best accepted practices, is far from satisfactory and can be improved considerably if and when proper research points the way. I would like to call your attention to two major examples of such evidence.

You are undoubtedly familiar with the excellent work of the Investigating Board, the Secretary of the Navy convened to inquire into the design and methods of construction of welded steel merchant vessels in an attempt to determine the causes and remedies for structural failures of Liberty ships. A great deal of this work was sponsorship of investigations and studies of notch sensitivity of ship plate, particularly at low temperatures, since it was the Board's conclusion that it was lack of notch toughness which contributed more than any other one factor to the failure of welded ships.[1a] As you remember, these studies resulted in a series of transition temperature curves for various steels used or which might possibly be used for ship construction. These curves showed that appreciable spread in transition temperature (50° F.), that is, temperature below which notch sensitivity rises rapidly, existed between different heats of semi-killed steel, and that further, considerable difference existed between the best of those steels and a fully killed and normalized steel (20° F.). As you remember, the specimen used to determine those curves was a $^{3}/_{4}$-in. thick, 72-in. wide plate containing an internal notch. Figure 5[2] shows the specimen and Tables 1[3, 4, 5] and 2[6] and Fig. 6[6,7] contain a brief review of the most pertinent data.

Table 3—Hatch Corner Tension Test Specimens[5]

Full Size Sections

	Steel Designation	Welding Electrode Type	Test Temp., ° F.	Maximum Nominal Stress at Failure, Psi.	Energy Absorbed, In.-Lb.	Fracture Type
Influence of temperature	C	E6010-E6020	32	23,200	...	Cleavage
	C	E6010–E6020	68	24,000	...	Cleavage
	C	E6010-E6020	72	24,800	...	Cleavage
	C	E6010-E6020	100	27,400	788,000	Cleavage
	C	E6010-E6020	120	25,600	484,000	Shear
	C	E6010-E6020	142	29,200	860,000	Shear
Influence of electrode	C	E6010-E6020	32	23,200	...	Cleavage
	C	Murex HTS	32	23,600	180,000	Cleavage
	C	310 (25–20)	32	27,700	232,000	Cleavage
Influence of preheat	C	E6010-E6020*	72	24,800	...	Cleavage
	C	E6010-E6020	72	29,400	...	Cleavage
	C	E6010-E6020†	70	32,600	1,046,000	Cleavage§
	C	E6010-E6020†	70	32,800	1,358,000	Cleavage
Influence of fabricating method	C	E6010-E6020	72	24,800	...	Cleavage
	C	(Riveted)	70	20,900	790,000‡	Cleavage
	C	(Riveted)	70	20,600	588,000‡	Cleavage
Influence of steel type	C	E6010-E6020	32	23,200	...	Cleavage
	D	E6010-E6020	32	25,900	...	Cleavage
	C	E6010-E6020	72	24,800	...	Cleavage
	D	E6010-E6020	72	27,800	1,196,000	Shear
	C	E6010-E6020†	70	32,800	1,358,000	Cleavage
	D	E6010-E6020†	31	33,000	952,000	Cleavage

* Stress relieved after welding—8 hr. at 1100° F.
† 400° F. preheat—no stress relief.
‡ Energy values high because rivet holes act as crack arresters.
§ Shear in welds.

However, I would like to direct your attention to another phase of research sponsored by the Board—the phase which dealt with tests of specimens reproducing full-scale ship sections.

Briefly, a series of sections reproducing exactly and on full scale, the corners of hatches on some of the earlier Liberty ships were pulled to destruction in tension on University of California's 3,000,000-lb. testing machine. The parameters studied were compositions of steel, welding procedures and temperatures. The design of the specimen and its appearance in the testing machine after fracture are shown in Figs. 7[8] and 8.[9]

You will note that the section is essentially a complex welded joint of extreme three-dimensional rigidity and containing what amounts to a severe notch in the center. An analysis of the stress at the corner or notch will reveal that appreciable tension stress normal to the major tension stress through the specimen exists in the weld and plate forming the corner, immediately inside the corner, as well as a steep stress gradient at the corner.

A brief summary of the results of the tests appears on Table 3.[9] From this summary, it can be seen that for a steel C which is a semi-killed steel with high transition temperature, welded with conventional procedure, increase in the temperature of the test produced little improvement in the performance of the specimen until temperatures over 100° F. were reached, when an appreciable increase in both maximum nominal stress in the section at failure and its energy absorption occurred. However, the best that was obtained was a maximum nominal stress of some 29,000 psi. with energy absorption of 800,000 ft.-lb. at a temperature of some 142° F. Substitution of fully killed steel D resulted in lowering of transition temperature from 100 to 72° F. That is, specimens made of relatively notch-tough steel performed at 72° F. as well, actually better, as those made from more notch-sensitive steel did at temperatures above 100° F. This, of course, was to be expected. However, and here comes what to me is a most significant point of this investigation, a change in welding procedure caused a specimen made of C, or notch-sensitive steel, to perform better at 70° than the notch-tough steel D welded with conventional procedures, did at the same temperature. This same beneficial change in the welding procedure on Type D or relatively notch-tough steel, dropped the transition temperature from 72° F. to 31° F. Furthermore C steel welded with improved welding procedure performed better than D steel welded with original welding procedure did at the same temperature, and D steel welded with improved welding procedure performed better at 31° F. than that same steel welded with the original procedure at 72° F. Therefore, it is tempting to conclude that a relatively random change in the welding procedure produced more benefit than a carefully deduced and planned change in steel.

It is interesting to note that the change in the welding procedure which accomplished this improvement was the use of 400° preheat in the fabrication of this specimen and that such changes as the use of 25–20 nickel-chrome welding electrodes and thermal stress relief after welding, although also beneficial, produced considerably less improvement than the 400° preheat. Incidentally, this provides interesting food for thought for those who are still inclined to think that locked-up stresses are detrimental to the strength of a welded structure, since 400° preheat does not reduce locked-up stresses to any appreciable extent.

The use of 25–20 welding electrodes produced a significant improvement in the maximum nominal stress at fracture. Unfortunately, the test was made at a temperature which was somewhat too low for the type of steel used. Nevertheless, it will be noted that at that temperature, the use of 25–20 electrodes did more good than the use of notch-tough D steel. It would be interesting to speculate as to exactly how good a performance could be obtained if the best welding procedure, whatever it may be, were used, since it is improbable that the 400 preheat procedure is the optimum obtainable.

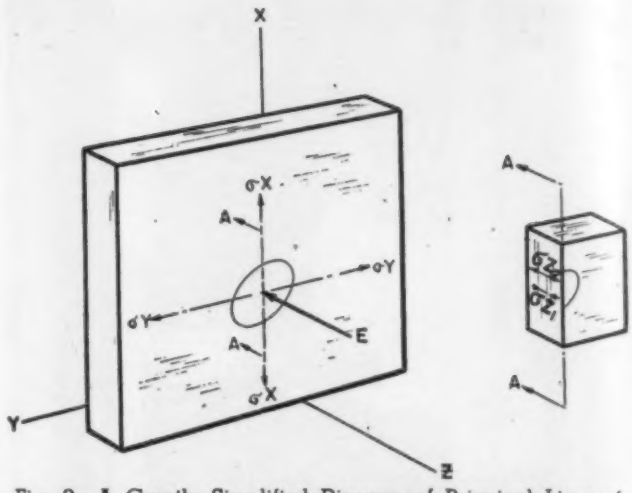


Fig. 9—A Greatly Simplified Diagram of Principal Lines of Stress in a Flat Plate Subjected to a Localized Impact *E*. In Section *A-A* the First Compressive Wave σZ_1 Is Shown as Well as the Tension Wave σZ_2 Produced by the First Wave σZ_1 After It Is Reflected from the Back of the Specimen

The hatch corner experiments provide some of the most convincing and direct evidence of inherent weakness of welded joints made with the currently accepted welding procedure since they represent tests on portions of actual structures.

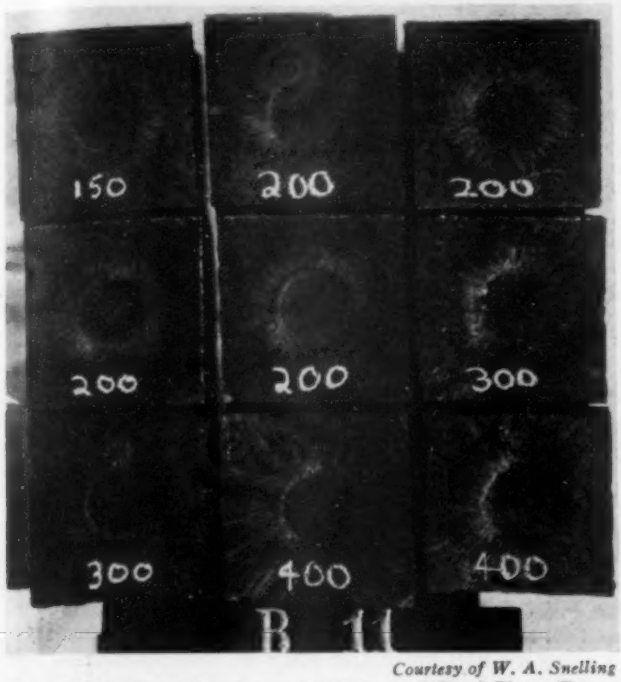
Unfortunately, there are a number of major difficulties in their use as a test specimen for wide study of performance of welded joints under combined stresses. The first is the time and expense required both by their fabrication and testing. The second is the fact that the specimen must be fabricated from component parts, which precludes a direct comparison between a welded and a homogeneous specimen, and the third is that the state of stress present at the critical point where fractures originate cannot be readily controlled.

Because of these difficulties, I would like to draw your attention to a second series of investigations which offers certain advantages even though it does not employ sections of actual structures, and the evidence it provides has to be interpolated to a large extent when applied to actual structures.

This second series of investigations used portions of simple butt-welded plates and attempted to evaluate their service performance by subjecting them to high velocity impact normal to the plane of the plate.[10, 11, 12]

The stress system produced in a plate subjected to a localized force acting in a plane normal to the plane of the plate is quite complex, and its rigorous analysis is yet to be made. However, certain general characteristics of such a system are fairly apparent. Briefly, application of a force to a point on the surface of a plate and normal to its plane will produce a compression stress under the point of application along the Z or thickness axis of the plate and equal tension stresses along both X and Y axes of the plane of the plate. Consequently, under the point of applications of this force and before appreciable strain takes place, there will exist a fairly uniform state of biaxial tension of ratio $X/Y = 1$, and a compression stress along Z or thickness axis of the plate. The magnitude of these stresses will be a function of the magnitude of the force and the magnitude of the resultant strain a

function of the energy applied. If the energy is applied in the form of a blow of sufficiently high velocity, the compressive stress along the Z axis will travel through the plate as an elastic stress wave which upon reaching the opposite surface of the plate will be reflected back toward the front surface in the form of a tension wave. Figure 9 illustrates this general system of stress.



Courtesy of W. A. Snelling

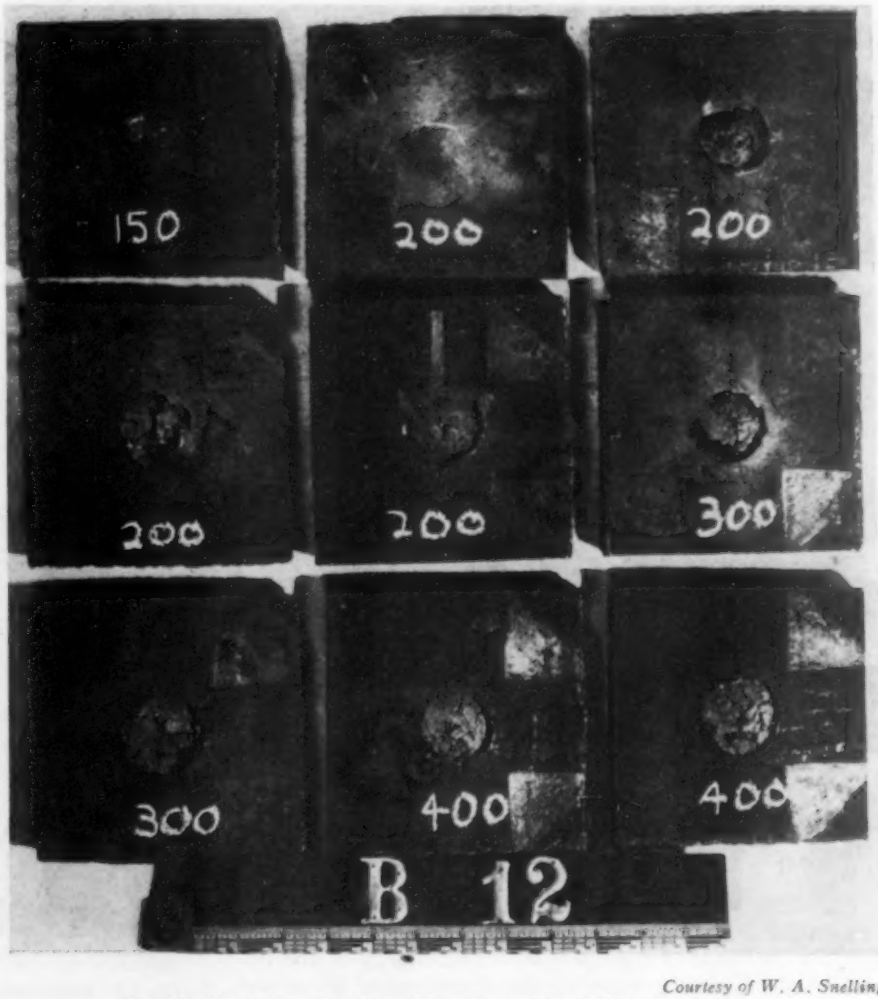
Fig. 10 *(a)*—Direct-Explosive Spall Test of Steel Plate (Front Face). (Note: Number on Plates Indicates Weight of Explosive Charge in Grams)

The duration of the reflected tension wave will be relatively brief since on reaching the front surface it will again be reflected as a compression wave. (Actually the picture is more complicated because the first or elastic wave is followed by a plastic compression wave which will travel at a much lower speed than the elastic wave so that the reflected tension wave will meet the plastic wave somewhere near the front surface rather than the point of its origin.) Nevertheless, for a brief period of time while the reflected tension wave travels toward the front of the plate, there will exist under the point of application of the blow, a state of triaxial tension. If we conceive of the blow as an application of finite quantity of energy composed of mass and velocity ($E = {}^1/_2\, mv^2$), it would appear that, at least within certain boundaries, the tension stress within the X-Y plane of the plate will be a function of the mass of the blow, while the tension stress along the Z or thickness axis will be a function of its velocity. Thus by controlling mass and velocity independently, fracture may be made to take place either in the plane parallel to the Z axis or in the X-Y plane.

It will thus be seen that in the case of a plate subjected to a blow, we have a mechanism for subjecting steel plate and simple joints to a state of triaxial tension with some degree of control over the relative magnitude of the stresses. Unfortunately this mechanism also superimposes on the state of the triaxial tension, the factor of high rate of strain. This, however, is not quite as bad as may appear at first glance, since there is very good evidence that the effects of high rate of strain and low temperature are fairly interchangeable and the test is probably equivalent to triaxial tension at low temperatures.

A survey of experience with joints subjected to localized blows reveals a number of interesting facts which I would like to review for your benefit.

The first study of the performance of welded joints subjected to localized impact was initiated by the requirements of the military materiel to withstand ballistic impact. Since the art of welding grew during the period between the two world wars, little information was available regarding performance of welded joints under the impact of artillery projectiles. It so happened that because of difficulties experienced during fabrication, most hardenable alloy steels were almost universally welded with austenitic chrome-nickel electrodes, and it soon developed that joints made with this procedure were fairly adequate for military purposes. When, however, fear of shortages of nickel and chrome made desirable conservation of these elements, it was soon found that welded joints made with conventional welding procedures were entirely inadequate even when radiagraphically sound welds with compositions and tensile strengths (as determined by standard 0.505 specimens) very nearly the same as those of the parent plate were obtained.



Courtesy of W. A. Snelling

Fig. 10 *(b)*—Direct-Explosive Spall Test of Steel Plate (Back Face)

This inadequacy was clearly demonstrated by the fact that an ordinary butt-welded joint 36 in. long would split wide open when subjected to a localized blow of but a fraction of the energy of the blow required to merely crack a prime plate of identical geometry and composition. Incidentally, this provided an excellent example of the fact that performance of a welded joint cannot be predicted on the basis of performance of its component parts under simple axial tension whenever the joint is subjected to anything but the simplest uniaxial tensile load.

It thus became fairly clear in the early days of the investigation that other means of testing performance of a welded joint, means which took into account its resistance to fracture under combined stresses and high rate of strain, must be developed. The most direct test, of course, was that of subjecting the joint to an impact of a projectile of certain mass traveling at reasonably high velocity, and such a test was indeed widely used. Useful as it was, however, this test had and still has drawbacks which make it ill suited to a general, quantitative study of performance of welded joints made with a wide variety

Fig. 11*(a)*—Base Plate for Explosive Test[10]

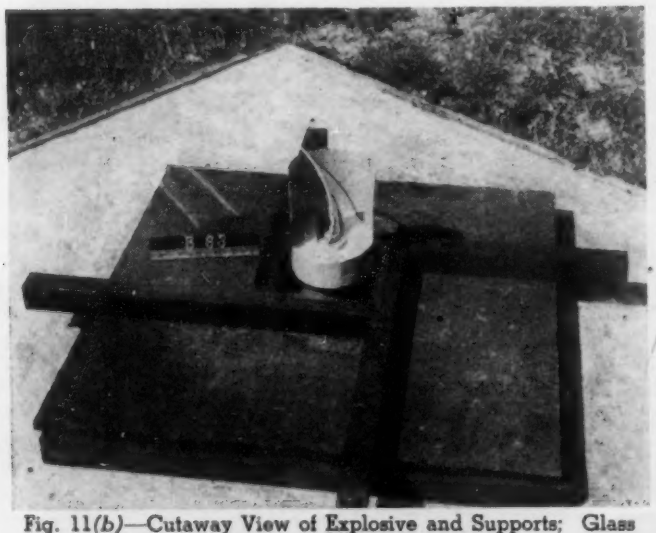


Fig. 11*(b)*—Cutaway View of Explosive and Supports; Glass Plate Represents Test Plate[11]

of materials and procedures. Briefly, in addition to great expense, the test is not sufficiently flexible because the two factors of mass and velocity cannot be controlled accurately and then only within narrow limits, and because, the exact point of application of the blow cannot be fixed. As a result another testing method fairly similar, but possessing less inherent limitations was developed and its use revealed a number of additional interesting facts.

This test[10] consists of substituting a blow produced by a detonating wave traveling through a column of explosive, for the blow of a projectile. The energy of the impact of a detonating wave is also composed of mass and velocity, the mass in this case being the mass of the

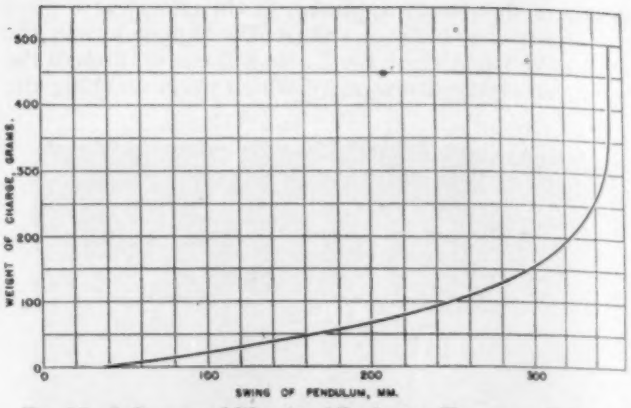


Fig. 12—Influence of Weight of Explosive Charge on Swing of Ballistic Pendulum.[10] (2-In. Diam. Pellets)

generated gases and the velocity being the velocity of detonation, but has the advantage that its point or area of application can be fixed exactly and that both of its two components can be varied independently of each other within a sufficiently wide range and with excellent accuracy of reproduction.

In applying the test to steel plate of a specific composition, either welded or unwelded, it has been found that each composition has a certain critical velocity above which the plate will fail along a plane parallel to its surfaces due to the tension stress in the Z or thickness axis. This failure will be in the form of a small slug or spall being torn out of the back of the plate immediately under the area of impact as illustrated on Figs. 10 (*a*) and 10(*b*).

It appears fairly certain that below this critical velocity, material will not spall regardless of the total amount of energy of the impact, but will fail in the same manner as do welded structures not subjected to shock loading, that is, by fracture normal to the plane of the component parts of the joint.

The critical velocities of the steels studied were found to be functions of the following factors: first, the tensile strength of the plate along its Z or thickness axis. Thus laminations or other physical discontinuities within the plate along this axis will lower the critical velocity radi-

Fig. 13—Deformation Produced in Flat Plate by Direct Explosive Test[11]

Fig. 14—Cross Section of Plate Shown in Fig. 13[11]

Fig. 15—Fracture in Plate Produced by Direct Explosive Test. This Plate Was Subjected to a Greater Explosive Charge than the Plate Shown in Figs. 13 and 14[11]

cally. Second, conventional tensile strength of the plate material along its X and Y axes, and third, the property we call notch toughness as evidenced by transition temperatures, or as I am tempted to describe it, the ability of material to undergo deformation under triaxial tension.

The critical velocities of mild steels were found to be in the neighborhood of 2000 meters per second, whereas those of quenched and drawn alloy steels appear to be between 3000 and 4000 meters per second.

It has been hypothesized by the investigators that if the velocity of the test is fixed just below the critical velocity of the steel tested, the ratio of stresses produced in the specimen will be as adverse as the material can ever expect to encounter in service and that, therefore, the amount of energy necessary to fracture the specimen at this just subcritical velocity can be considered as a fair measure of the performance of the steel plate or joint tested under most severe service stresses possible. If

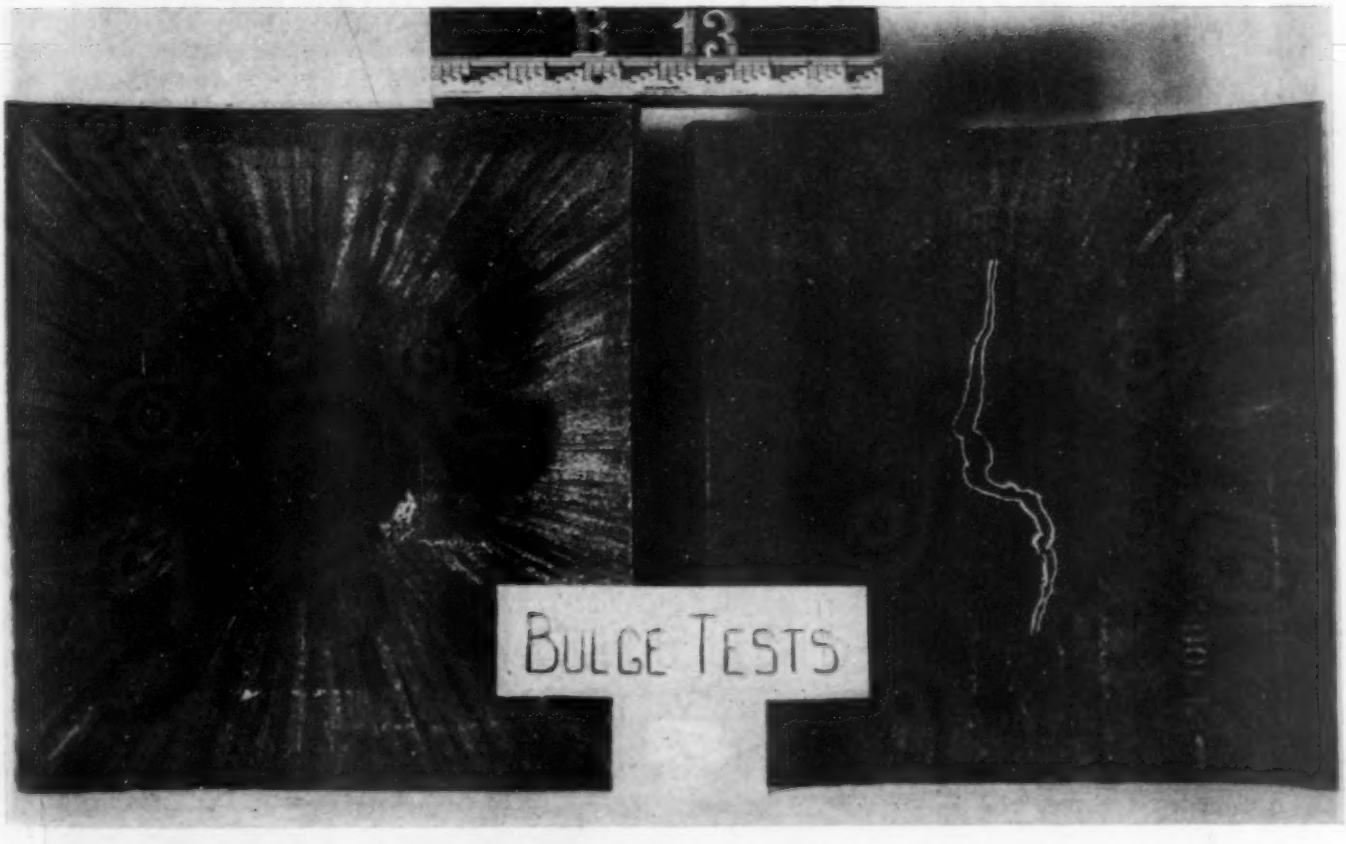


Fig. 16—Direct Explosive Test of High-Tensile, Low-Alloy Steel Having Good Notch Toughness[10] (Front Face)

Fig. 17—Same Pair of Plates as Shown in Fig. 16 (Back Face)

this hypothesis is accepted, the test becomes an extremely useful tool for studying performance of welded joints under triaxial tension, and the comparatively meager data gathered so far are well worth most careful scrutiny. Before doing this, however, I would like to remind you of the major details of the actual mechanics of this test.

The specimen to be tested, usually consisting of a 12- x 12-in. or 18- x 18-in. prime or welded plate, is supported as shown on Fig. 11 (*a*) and a measured quantity of explosive of desired detonating velocity is placed on the portion of the specimen to be tested as shown on Fig. 11 (*b*).[11] The total impact exerted by the detonation on the supporting specimen is a function of the density, geometry and of the detonating velocity of the explosive and its energy can be measured with fair accuracy by means of a ballistic pendulum. The relationship between the total energy of impact and the weight of explosives over a unit area of application can then be expressed by a family of curves, one for each velocity of detonation used. Figure 12[10] shows a curve typical of this family. Each test requires a number of identical specimens, since progressively larger charges are applied until failure occurs.

It will be noted that within certain limits the relationship between weight of explosive per unit area of application and energy delivered is nearly linear and for this reason all work to date has been conducted within these limits which appear to contain sufficient energy to fracture the toughest of specimens tested.

The most critical part of the test is accurate reproducibility of the detonating velocity selected (which is a function of the chemistry, particle size and density of the explosive) since the energy, of course, varies as the square of the velocity. However, it has been possible to develop methods for accurate control of the detonating velocities to the point where scatter in test data is amazingly low.

In the past work, the areas of impact were usually selected with some reasonable regard for the geometry of the plate and of the weld. Cylinders of explosive, 2, 3 and 4.15 in. in diameter, have been used on $^1/_2$- to $1^1/_2$-in. thick plate.

On examining the results of the tests conducted to date, one of the most interesting facts revealed is the difference in the mode of fracture of specimens made of notch-sensitive and notch-tough plate. Whereas notch-tough plates fail by a single or a Y-shaped crack, which usually first

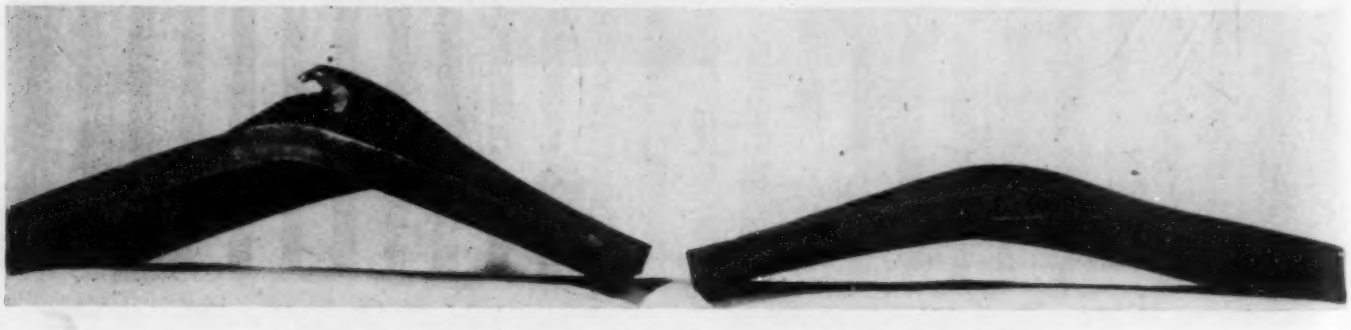


Fig. 18—Same Pair of Plates as Shown in Fig. 16 (Edge View)

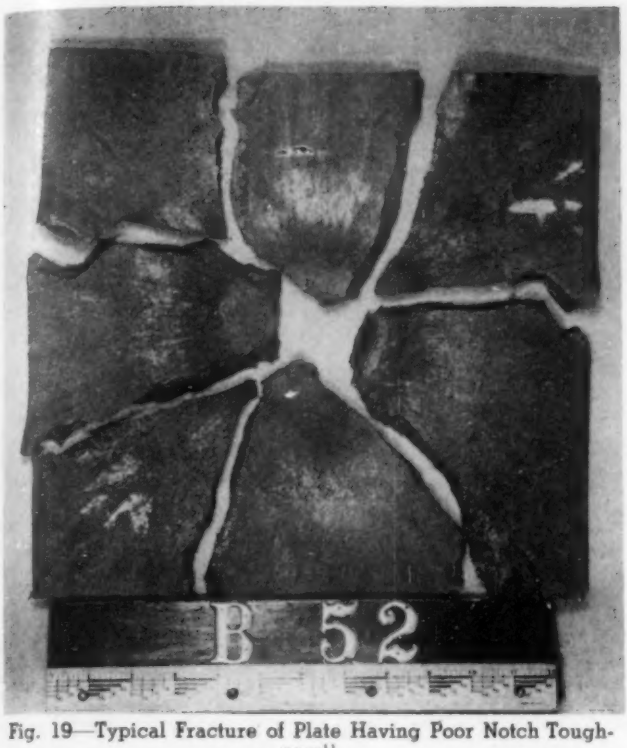


Fig. 19—Typical Fracture of Plate Having Poor Notch Toughness[11]

starts on the back of the plate and the dimensions of which are a reasonable function of the energy of the impact, notch-sensitive steels shatter into many pieces without any subsequent cracking, so that there does not appear to be any transition between no failure and complete failure. Furthermore, the notch-sensitive steels usually fracture with comparatively little deformation. In the notch-tough steels, the extent of deformation varies considerably depending on the ultimate tensile strength and elongation (as determined by 0.505-in. specimens). However, despite the fact that in the notch-tough steel the

Fig. 20—Typical Fracture (Through Weld Metal) of Weldment Fabricated with Plate Having Good Notch Toughness[11]

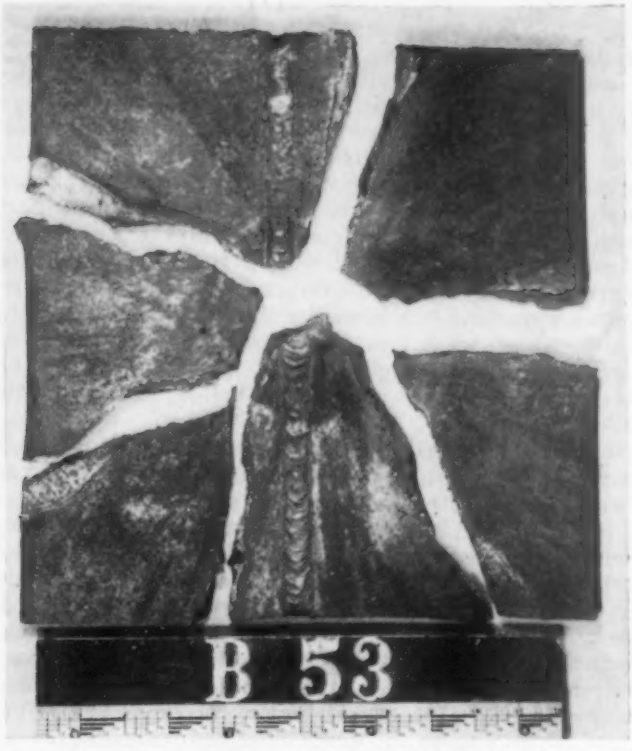


Fig. 21—Typical Fracture (Through Plate) of Weldment Fabricated with Plate Having High Poor Notch Toughness[11]

deformation of low-tehsile ductile steels is greater than that of high-tensile alloy steels, the energies necessary to fracture the latter are very much greater.

Figures 13,[11] 14[11] and 15[11] show performance of steel plate of good notch toughness, medium tensile strength and high ductility. It will be seen that the plate underwent a high degree of deformation before fracture having been drawn into nearly a hemisphere.

Figures 16,[10] 17[10] and 18[10] show performance of high-tensile alloy steel of extreme notch toughness. Here the maximum deformation produced at fracture is considerably smaller even though the energy required was nearly five times as great as that for plate shown on preceding

Fig. 22—Front View of Manually Welded 1.5-In. Plate Exhibiting Poor Shock Resistance

Figs. 13,[11] 14[11] and 15.[11] Figure 19[11] shows performance of notch-sensitive plate.

Such in general are the broad characteristics exhibited by prime steel plate when subjected to the direct impact test. Insufficient work has been done to date to establish more than these general trends, but so far they appear to correlate fairly well with performance of steel plates studied at California by means of a notched specimen 72 in. wide. For instance, transition temperature of C steel was some 70° higher than that of D steel, and correspondingly under the direct impact test, steel C required considerably less energy to fracture than steel D. Furthermore, while steel D underwent considerable deformation prior to fracture as can be seen from Fig. 14, steel C deformed but very little, before shattering into several pieces.

Let us now consider performance of butt-welded plate specimen as compared to prime plate specimen. As you remember the butt-weld specimen consisted of two pieces of plate butt-welded together to form a plate of geometry identical to the prime plates tested. Under most conventional tests, performance of such a welded plate would be virtually indistinguishable from the performance of the prime plate, particularly so in case of ordinary mild steel welded with 6010 electrodes. Under direct impact test, however, the performance of a welded specimen ranges from 25% to 90% of that of its component prime plate, depending on the qualities of the plate and on the welding procedure used.

Under no procedures attempted, however, was the performance of the welded joint quite as good as that of the prime plate, even though on quenched and drawn alloy steels made with special welding procedures, performance very nearly as good as that of the parent plate was obtained. The most common performance of welded plate was approximately 50% of the prime plate.

Here again the mode of fracture of tough and brittle welds was quite different. In case of joints made of extremely notch-tough plate, the failure usually took place through the weld; the fracture traveling either through the weld metal or through the heat-affected zone of the parent metal. In case of notch-sensitive steels, however, the specimen usually shattered in several pieces in much the same manner as did the parent plate; in case of intermediate steels, that is, steels with only fair notch-toughness such as for instance, D steel, presence of the weld made the specimen behave like notch-sensitive steel;

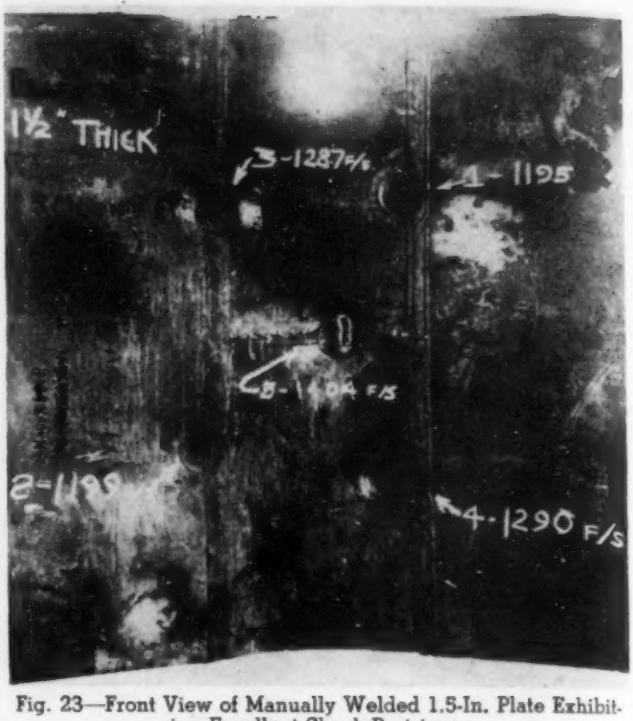


Fig. 23—Front View of Manually Welded 1.5-In. Plate Exhibiting Excellent Shock Resistance

Table 4—Explosive Test Results[11,12]

12 x 12 x 1-In. Plates

Steel Designation	Chemical Composition, %								
	C	Mn	Si	P	S	Cu	Ni	Ti	V
DC	0.16	1.29	0.27	0.022	0.022	...	...	0.013	...
MC	0.14	1.29	0.18	0.029	0.040	...	...	0.015	...
EA	0.15	1.19	0.30	0.020	0.024	0.06	0.15	0.013	0.031
AA	0.23	1.53	0.33	0.016	0.029	0.15	0.20	0.008	0.005
X	0.18	0.43	...	0.021	0.025	...	...	...	...
D*	0.18	0.55	0.23	0.015	0.028	0.020	...	...	...

Steel Designation	Electrode Type	Charge to Break Plate, Gm.	Deformation at Fracture (Dish), Mm.
	Prime Plate		
DC	...	600	52
MC	...	600–625	54
EA	...	575	49
AA	...	465	40
D	...	400–425	75
	Welded Plate		
DC	E6010	350	40
DC	HTS	550	40
MC	E6010	240	29
MC	HTS	510	45
EA	E6010	225	29
EA	HTS	475	35
AA	E6010	180	18
AA	HTS	325	26
X	E6010	200	60
X	E6010 SR†	230	66
D	E6010	200	55
D	E6010 FSR†	250	61

* Normalized.

† SR—Low temperature Sun-Linde torch stress relief. FSR—Furnace stress relief—1 hr. at 1100° F.

whereas the prime plate behaved like notch-tough steel.

Figure 20[11] shows a typical fracture of a weld made on reasonably notch-tough plate, whereas, Fig. 21[11] shows a fracture of a welded specimen made of notch-sensitive steel.

A summary in Table 4[11, 12] presents some of the typical results obtained on welded low and medium tensile plate with the direct impact test. It will be noted that performance of the best notch-tough plate welded with conventional welding procedure was approximately half as good as the performance of that same plate in the unwelded condition and worse than the performance of the most notch-sensitive plate in the unwelded condition. Thus while improvement in the plate raised the energy necessary to fracture the plate from 465 units to 600 units, the introduction of a welded joint reduced the energy to fracture the best plate from 600 to 350 units, and of the worst plate from 465 to 180 units. It is also interesting to note that of the several welding procedures used, substitution of a special electrode, having a different gas content in the arc atmosphere resulted in most benefit.

As you may remember in case of hatch corner specimens, although no comparison was possible between the use of a completely homogeneous and a fabricated specimen as it is obviously not feasible to roll or forge a hatch corner specimen in one piece, changes in the welding procedure produced improvements in the performance of the specimen at low temperature as great if not greater than improvements in the material. That same trend now appears in the direct impact test. All of which seems to indicate the need for further studies of performance of joints welded with different procedures under services which may contain conditions of combined stresses, or rapid rates of strain, or low temperatures, or any combinations of these three.

During the War, considerable work was done in this direction for one particular type of steel with fairly satisfactory results. Although the procedure developed was not entirely practical for quantity production, a tremendous improvement in performance was effected. Figures 22 and 23 show performance of two fairly large butt-welded specimens when subjected to a direct impact test. The specimen welded with the best prewar welding procedure failed completely at an impact of the minimum energy possible in the test used. The specimen welded with the special procedure developed, withstood five impacts, each one of which had energy three to four times as great as the energy of the single impact which fractured the specimen welded with the conventional procedure. I may add that both specimens were radiagraphically sound and that the conventional tensile properties of the weld metal and of the heat-affected zone as determined by standard 0.505 tensile tests were practically the same for both specimens and very nearly the same as those of the parent plates. The parent plate of both specimens was the same.

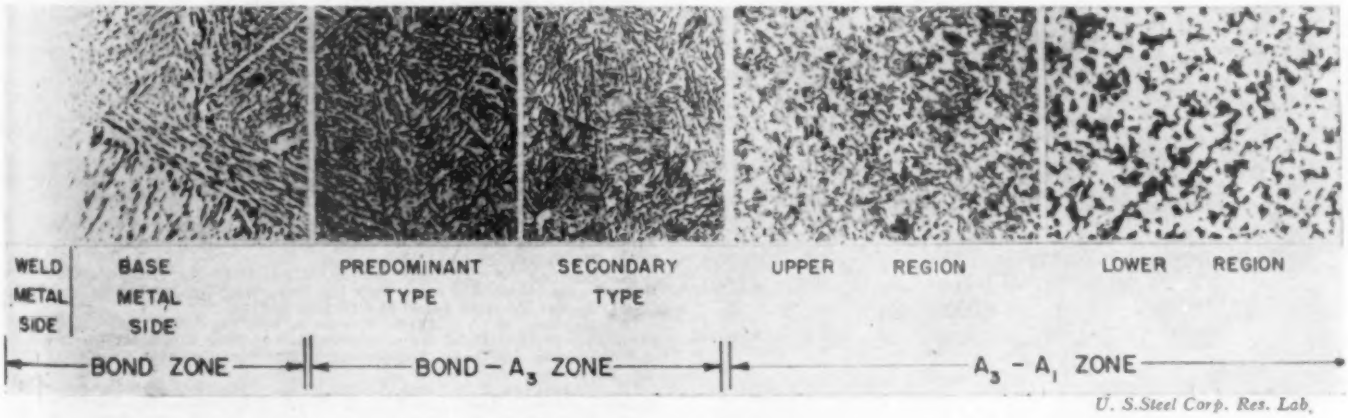
Table 5—Relative Volume of Gases Produced in the Arc Atmosphere of E6010 and Lime-Ferritic Electrodes[14]

Gas	Electrode	
	E6010	Lime-Ferritic
H_2	45.8	13.5
CO	52.2	72.5
CO_2	2.0	14.0

Comparable work remains to be done for other more commonly used steels, and I sincerely hope that this discussion may go at least a short way toward stimulating the needed research.

In conclusion, it might be interesting to consider some of the factors which may be responsible for the apparent inferiority of the welded joint to the parent plate. One of the factors is undoubtedly the metallurgical difference in the structures of the weld metal and of the heat-affected zone and that of the parent plate. As you well know, the welding process produces a great variety of structures in the weld area, as may be seen from Figs. 24 and 25[13] which are typical of mild and alloy steel welds, respectively. It is not surprising that some of these structures have properties which are unsatisfactory from a point of view of resistance to fracture and to deformation under combined stresses. Here again, however, little faith can be placed in the behavior of these structures under conventional tensile test, in so far as ability to predict their performance in a welded joint is concerned. For instance in the heat-affected zone shown on Fig. 25, the A1-A3 region which has large areas of free ferrite, will exhibit greatest ductility and elongation under a standard 0.505 specimen tensile test, yet it is precisely in this area that failure is apt to occur under a direct impact test as may be seen from Fig. 26.

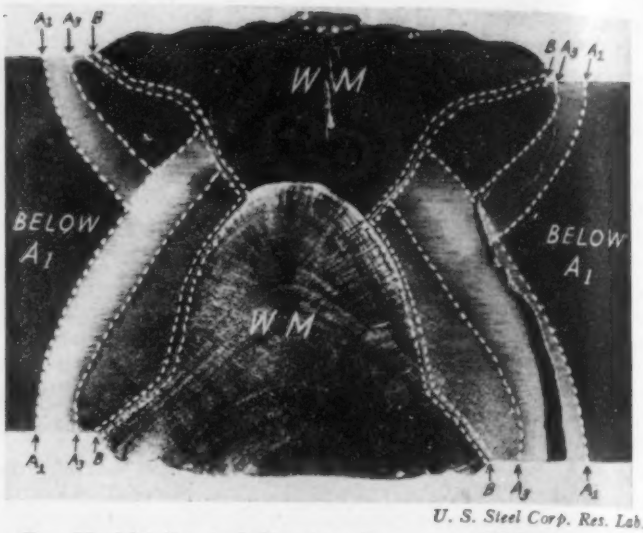
The second factor which is less understood is the effect of the gas composition of the arc-shielding atmosphere. Some of the most spectacular improvements in the performance of welded joints have been made possible by changes in the arc atmosphere. Although considerable work has been done in analyzing the arc atmospheres produced by different types of electrode coatings (Table 5)[14] little is understood of the mechanism, by means of which the arc gases affect the properties of the welded joint.



U. S. Steel Corp. Res. Lab.

Fig. 24—Typical Microstructure in the Heat-Affected Region of Si-Cr-Mo-Zr Alloy Steel

One of the most plausible theories is that which postulates that molecular hydrogen trapped during transformation in microscopic rifts and intergranular voids under considerable pressure, inhibits plastic flow under combined stresses. This theory, substantiated by the fact that reduction of hydrogen in the arc atmosphere is usually beneficial in improving the performance of the welded joint, has, however, some apparent inconsistencies and is not altogether satisfactory. Undoubtedly other dissolved gases, such as oxygen and possibly nitrogen, also have profound effect upon the properties of the weld area.



U. S. Steel Corp. Res. Lab.

Fig. 26—Metallurgical Structure Zones in a Welded 1.5-In. Plate

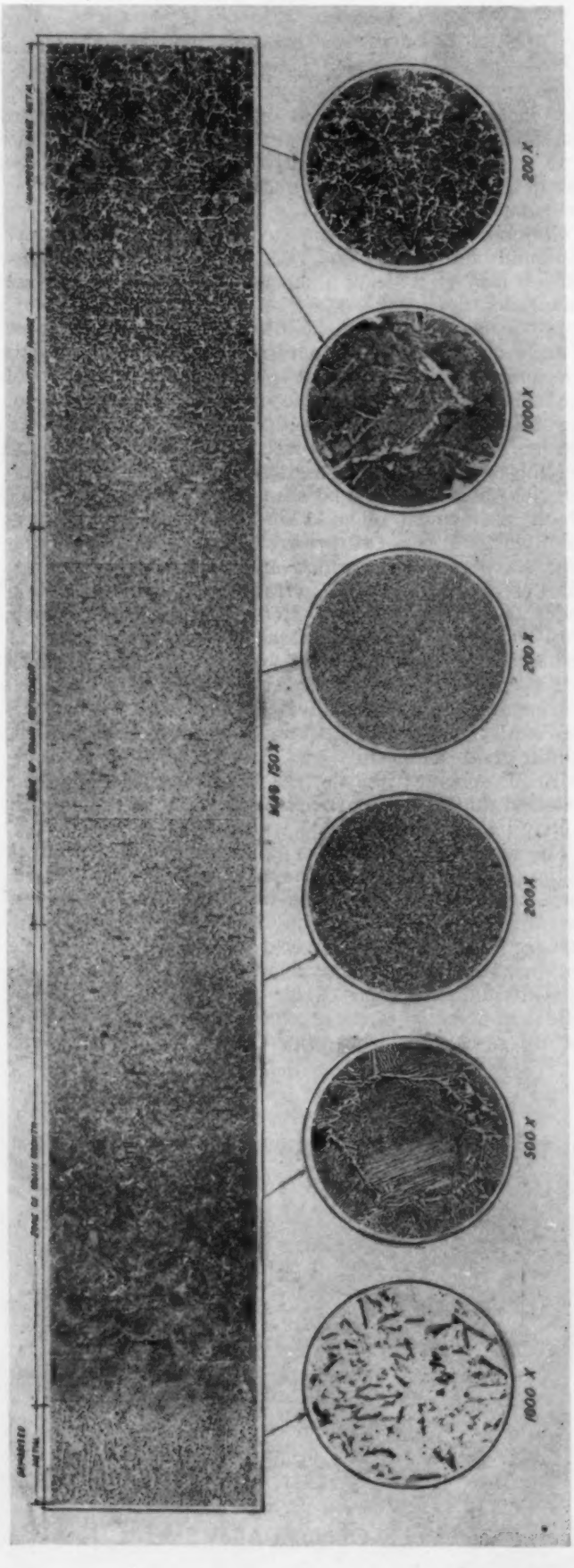


Fig. 25—Structural Changes in the Temperature Gradient of a Weld[13]

It seems to me that one of the most important steps in the research which I hope will come, will be the understanding of the fundamental mechanism of welding and of the relationship between the chemical and physical structure of steel affected by welding and its properties of resistance to fracture and resistance to deformation under combined stresses, different rates of strain and different temperatures.

Bibliography

1. Gensamer, M., Saibel, E. A., and Ranson, J. T., "Report on the Fracture of Metals," THE WELDING JOURNAL 26, (8), Research Suppl., 443-s to 484-s (August 1947).

1a. Final Report of a Board of Investigation convened by order of the Secretary of the Navy to inquire into "The Design and Methods of Construction of Welded Steel Merchant Vessels," July 15, 1946.

2. Wilson, Wilbur M., Hechtman, Robert A., and Bruckner, Walter H. "Cleavage Fracture of Ship Plates as Influenced by Size Effect," Preprint A.W.S. Annual Meeting, Chicago, Ill., Oct. 20–24, 1947.

3. Gensamer, M., Klier, E. P., Prater, T. A., Wagner, F. C., Mack, J. O., and Fisher, J. L., "Correlation of Laboratory Tests with Full Scale Ship Plate Fracture Tests," Committee on Ship Construction, Division of Engineering and Industrial Research, National Research Council, Serial No. SSC-9, March 19, 1947.

4. Klier, E. P., Wagner, F. C., and Gensamer, M., "The Correlation of Laboratory Tests with Full Scale Ship Plate Fracture Tests," Preprint, A.W.S. Annual Meeting, Chicago, Ill., Oct. 20–24, 1947.

5. Wilson, W. M., Hechtman, R. A., and Bruckner, W. H., "Cleavage Fracture of Ship Plates as Influenced by Size Effect," Committee on Ship Construction, Division of Engineering and Industrial Research, National Research Council, Serial No. SSC-10, June 12, 1947.

6. Davis, Harmer E., Troxell, G. E., Parker, Earl R., Boodberg, A., and O'Brien, M. P., "Causes of Cleavage Fracture in Ship Plate—Flat Plate Tests and Additional Tests on Large Tubes," Committee on Ship Construction, Division of Engineering and Industrial Research, National Research Council, Serial No. SSC-8, Jan. 17, 1947.

7. Boodberg, A., Davis, H. E., Parker, E. R., and Troxell, G. E., "Causes of Cleavage Fracture in Ship Plate—Tests of Wide Notched Plates," Preprint, A.W.S. Annual Meeting, Chicago, Ill., Oct. 20–24, 1947.

8. DeGarmo, E. Paul, "Tests of Various Designs of Hatch Corners for Ships," Preprint, A.W.S. Annual Meeting, Chicago, Ill., Oct. 20–24, 1947.

9. DeGarmo, E. Paul, Meriam, J. L., and O'Brien, M. P., "Causes of Cleavage Fracture in Ship Plate: Hatch Corner Tests," Committee on Ship Construction, Division of Engineering and Industrial Research, National Research Council, Serial No. SSC-5, Oct. 23, 1946.

10. Snelling, W. A., and Snelling, W. O., "Direct Explosion Test for Welded Armor and Ship Plate, Part I—Armor (OD-76)," OSRD Report No. 4655 Serial M-446, Jan. 23, 1945.

11. Snelling, W. A., and Snelling, W. O., "Direct Explosion Test for Welded Armor and Ship Plate, Part II—Prime and Welded Plate (NS-255)," OSRD Report No. 6382, Serial M-622, Dec. 5, 1945.

12. Snelling, W. A., "Direct Explosion Test for Armor and Ship Plate: Prime and Welded Plate Tests," Committee on Ship Construction, Division of Engineering and Industrial Research, National Research Council, Serial No. SSC-4, Aug. 30, 1946.

13. Davenport, E. S., and Aborn, R. H., "Metallurgical Aspects of the Welding of Steel," AMERICAN WELDING SOCIETY JOURNAL, (October 1936).

14. Voldrich, C. B., Rieppel, P. J., Mallett, M. W., and Russell, H. W. "Development of Improved Electrode Coatings (OD-36-2)" OSRD Report No. 4394, Serial M-371, Nov. 12, 1944.

A Clinical Approach to Weldment Design*

By Gerald von Stroh†

A CLINICAL approach to the design of weldments is a study of the behavior of welded structures, particularly failures of welded structures, during and after their service life, much in the same manner that a physician approaches a human ailment and learns from it.

The need for such a clinical approach is the result of a combination of features peculiar to weldments, such as the frequently overlooked fundamental that a welded structure is one piece of metal and that for economical reasons that one piece of metal may have designed into it internal and/or external notches and incipient cracks. Such notches and cracks, as will be discussed later, may drastically affect the endurance limit of the welded structure.

In a statically loaded structure, such as a bridge or building, endurance limit as a design factor is of little or no importance. For practical purposes there are no reversals of stress applied to the structure.

On the other hand, dynamically loaded structures such as machinery parts, automotive parts, railroad car and locomotive parts, and chemical or processing equipment subjected to thermal stresses and changes in pressure are structures whose service life depends upon their ability to withstand repetitive reversals of stress. Therefore, endurance limit or fatigue characteristics of the gross structure become in the final analysis the design criteria rather than ultimate or yield values of the material involved. Since endurance limit, as will be shown later, is extremely sensitive to notches, cracks and shape it becomes apparent that the greatest need for a clinical study of weldments lies in the field of dynamically loaded structures. Therefore, the comments and conclusions of this paper will be confined to dynamically loaded structures.

A clinical study of weldment design should utilize laboratory and mathematical methods of stress determination to the fullest extent possible. However, their use should be tempered with a realization of their limitations.

Experimental stress analysis of a gross structure will give stress levels, but it will not tell how long the structure subjected to reversals of stress will live at those levels.

There are no systems of mathematics which will determine the fatigue value of a gross structure. Usually we will take the known static loads, apply a factor of safety or of "ignorance" and trust all will be well.

Full-size fatigue testing of a gross structure will essentially give us the required data, but unfortunately full-scale fatigue testing is usually too expensive and the structures too large to make this a practical method for many applications of welding.

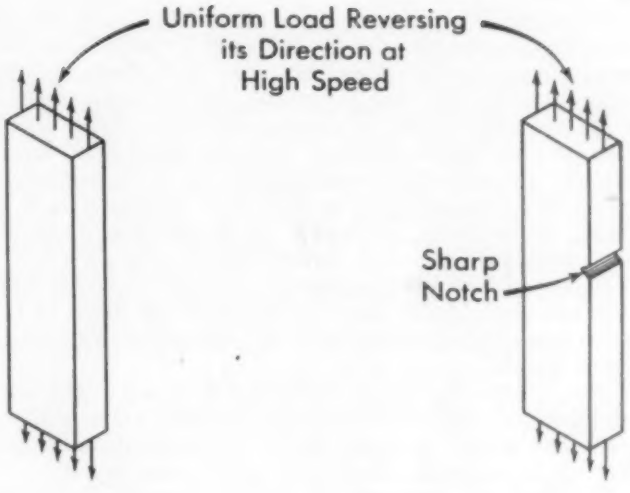


Fig. 1 Fig. 2

Fig. 1—If Load Is Applied to a Steel Bar and Reversed Parallel to Length of Bar and Uniformly Over Its Cross Section, Its Endurance Limit Will Be About One-Half Its Ultimate Strength. Fig. 2—If the Bar Is Notched, as Shown, Its Endurance Limit Will Be Considerably Reduced

It would appear, therefore, that the practical course is to use conventional methods for proportioning the members of a structure and by clinical study of service behavior develop a qualitative feeling for what is good practice to permit the gross structure to function in a predictable manner.

As a first step to a clinical study of weld failures, and in view of the fact that a weldment is one piece of metal, consideration should be given first to the characteristics of one piece of steel under dynamically loaded conditions.

Figure 1 pictures an ordinary well-made structural steel with a yield point between 30,000 and 40,000 psi. If a load is applied to it and reversed—parallel to the length of the bar and uniformly over its cross section—its endurance limit will be approximately one-half its ultimate strength.

If the bar is notched, as shown in the illustration in Fig. 2, the endurance limit, expressed in pounds per square inch, will be considerably reduced.

A profound fact (involving the constantly increasing use of high-strength steels in weldments) recognized by the more "scientific" researchers but often blandly ignored by so-called "practical" designers should be emphasized at this point.

Conventional fatigue specimens are made carefully to avoid stress concentration at the critical section. The endurance limit obtained from conventional specimens increases approximately in proportion to the tensile strength.

---

* Contributed by the Production Engineering Division for presentation at the Annual Meeting, Atlantic City, N. J., Dec. 1-5, 1947, of the American Society of Mechanical Engineers.

† Assistant Manager, Development Engineering, Lukens Steel Co., and Divisions, By-Products Steel Co., Lukenweld, Coatesville, Pa.

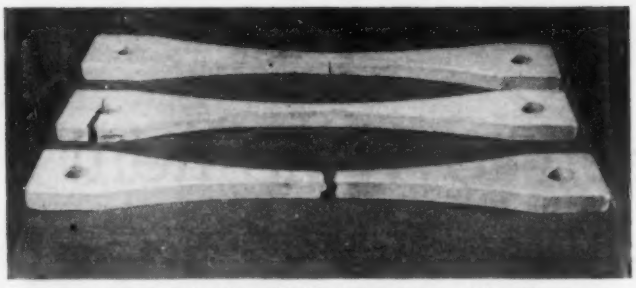


Fig. 3—Three High-Alloy Welded Specimens After Testing in Fatigue Machine at Stress of 34,200 Psi.

In other words, if a high-strength steel is used, its endurance limit under ideal conditions is proportionately increased.

However, if a sharp notch is introduced, as in Fig. 2, the fatigue strength is about the same for high- and low-strength materials. This indicates that there is little value in using the more expensive high-strength steels in a dynamically loaded structure wherein notches exist. Despite this, there are many dynamically loaded structures in service today involving the use of high-strength steels with innumerable stress raisers of this nature in them. Frequently, it seems, high-strength materials have been used in a very unintelligent manner.

Recently, four specimens were run in a fatigue machine at a stress of 34,200 psi. Figure 3 shows three of the specimens after the test, the fourth is being retested at a higher stress.

Two specimens did not fail where it was thought they might despite 5,000,000 reversals of stress. One of these —the one shown in the center of the illustration—failed through a connecting bolt hole, shown at the left.

The bottom specimen in the illustration failed at 3,000,000 cycles, following an accident which happened at 72,000 cycles. The accident occurred when the adapter broke, bending the specimen. It was straightened subsequently and the test was resumed. The endurance life of the specimen was affected materially by the accident.

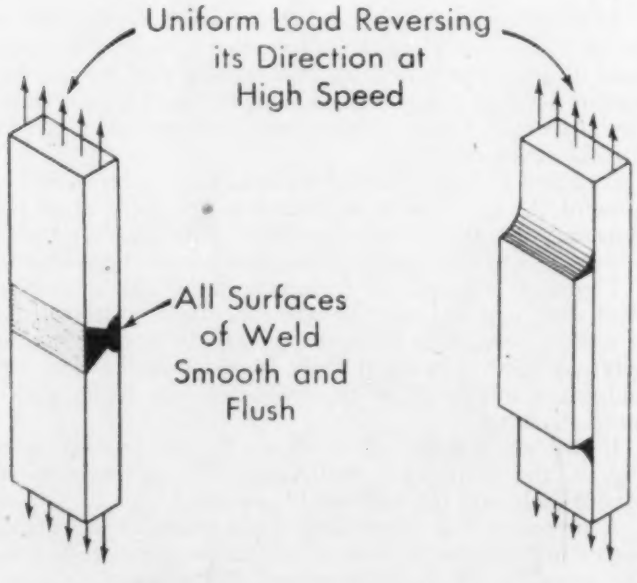


Fig. 4 Fig. 5

Fig. 4—Specimens Pictured in Fig. 3 Were Welded as Shown in Fig. 4

Fig. 5—A Second Principle of Welding Is Shown Here. Weldments Are Being Designed in This Manner Despite Failures

The history of this specimen indicates, in a general manner, the sensitivity of materials under such conditions.

From one standpoint, this test is a very satisfactory performance, although it cannot be a final determination of endurance limit. This seemingly insignificant experiment was carried on for the practical reason of showing that a welded joint can be executed with an endurance limit approximating that of the parent metal.

If the weld is not internally sound with smooth, external contours the life of such a specimen would be shortened materially.

This is evidenced by the upper specimen shown in Fig. 3. An internal defect in the weld reduced its life to 1,400,000 cycles in contrast to 5,000,000 on two other identical specimens.

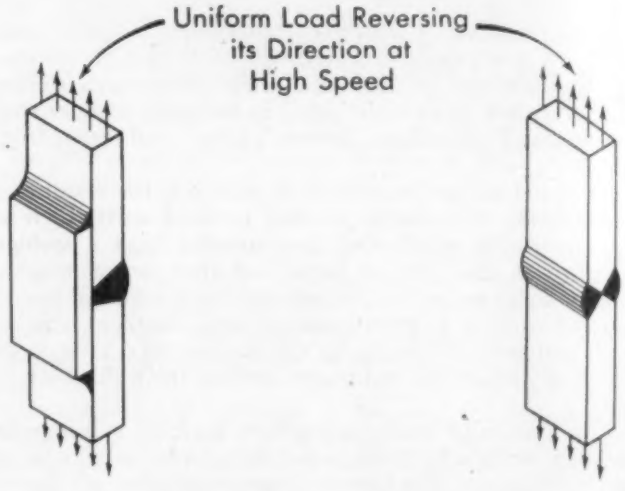


Fig. 6 Fig. 7

Fig. 6—Another Type of Weldment, Little Improved Over That Shown in Fig. 5

Fig. 7—Welded Joint with Reinforcements. Most Specifications Now Limit Such Reinforcements to Thicknesses of $^1/_8$ In.

The specimens just described were welded as shown in Fig. 4. A second principle is illustrated in Fig. 5. By means of fatigue machine investigations, it has been determined, definitely, that the addition of material as shown shortens the life of such a dynamically loaded sample.

Weldments, so loaded, are being designed as shown in Fig. 5, despite the fact that some of them have failed. Such construction necessarily should not be eliminated, since certainly many liberties can be taken in regions subject to secondary loading conditions.

Weldments are still being designed with variations of the conditions shown in Fig. 6. This type of weldment is little improved over the one described in Fig. 5. Here, the judicious use of such conditions is entirely proper. However, the designer must, of necessity, have a nice feeling when and where such construction might be used without distress.

At one time, welded joints were specified with so-called reinforcements as shown in Fig. 7. However, most specifications now limit such "reinforcements" to $^1/_8$-in. thicknesses.

Why a weld of the type shown here is specified is an unanswered question. Perhaps the idea is to provide more metal, on the chance that the joint would not be so good as expected for one reason or another.

Why such conditions, as shown here, will have an effect upon the fatigue strength of a piece of steel might be considered briefly. If this piece of steel were considered as a pipe with fluid running through it under high pressure, it

would be seen readily where turbulence would occur. To a certain degree, stress, while it is an intangible, flows through a piece of steel and a gross structure much in the manner that fluid flows through a pipe and pipe system. Wherever turbulence would occur, if the structure were a system of pipes, an interruption in the flow of stress would occur and cause a stress concentration. If a designer will carry this simple analogy in his mind when designing a welded structure and bear in mind the fact that a weldment is one piece of metal, he probably will design a more predictable weldment.

Figure 8 shows a structure in which failure occurred at a design detail similar to that just described. It is obvious that the designer could not predict the occurrence of failure in this car frame, otherwise it would not have occurred. Depending on the usual flexure formulas, estimating loads imposed and applying the factor of safety, the designer disposed his material.

Two design uncertainties of vast proportion existed in this structure. First, the stress augment due to impact could only be guessed. Such unpredictable impact forces are twofold in such a structure.

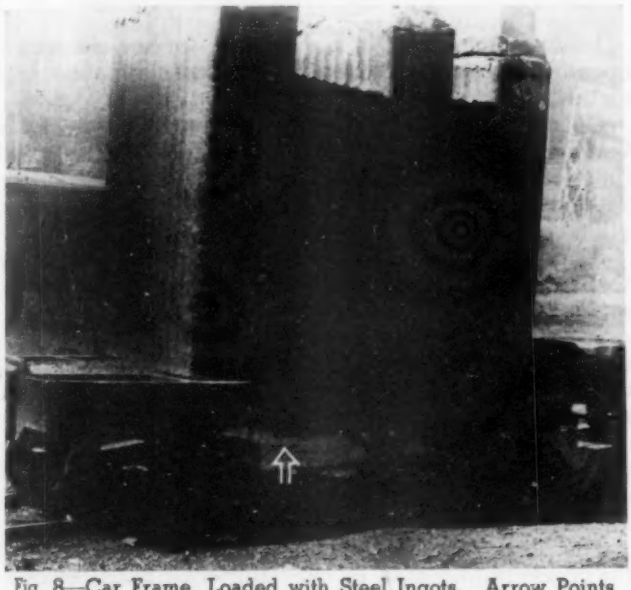


Fig. 8—Car Frame, Loaded with Steel Ingots. Arrow Points to Location of Eventual Failure

The designer cannot control definitely the maximum load or the ease with which it is applied. Loading of slabs or ingots can affect peak stress levels tremendously with the impact varying considerably.

Second, the superimposed stresses due to impact while the car is in motion, likewise, could only be surmised. Such stress augment varies, of course, with speed, track conditions and general handling, such as coupling.

These unpredictable factors, naturally suggest the use of experimental stress analysis so that operating stresses on pilot models can be determined definitely.

The second important design uncertainty involved here is the notch sensitivity at the point of fracture. This point was in the side member of the car in this illustration below the left and center ingots.

The fracture occurred at the end of an inner reinforcing member that cannot be seen in the illustration. While such a notch effect externally is large it is still a notch. An abrupt discontinuity of metal occurs at the point of fracture.

The designer did have a measure of control here if he possessed a proper feeling for elastic and plastic actions of steel plate. He could have eased the contour at the change in metal sections by making it gradual, and this would have permitted a smooth flow of stress.

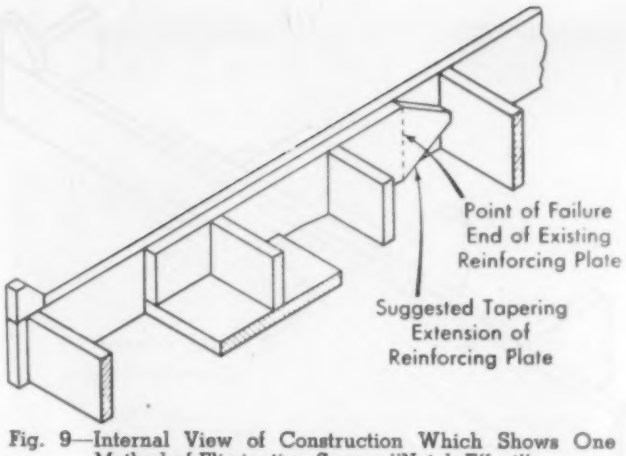


Fig. 9—Internal View of Construction Which Shows One Method of Eliminating Severe "Notch Effect"

Figure 9 shows an internal view of the construction, which pictures one method of achieving a gradual change in metal section. This is only one of the methods that can be used to achieve the same end.

It is simply a tapering extension on the reinforcing member which provides a gradual change in the rigidity of the structure at this point, thus eliminating the severe "notch effect."

The designer's knowledge or feeling in proportioning such an "easement" is, however, purely qualitative. He had no quantitative values or methods dictating the proportioning of this gradual change in section.

Some may believe that such detail can be determined mathematically but proof of any such methods applied under dynamic conditions remains to be seen.

Considering the number of unknown factors in this instance, "speculative designing" certainly existed. Without experimental analysis or without good luck, hundreds of such structures could have been put in use before weak spots were discovered. All this, of course, is one reason for the emergence of "experimental stress analysis" as an organized function of engineering.

While a failure in the previous illustration could not be pictured, Fig. 10 shows that a failure did exist in this structure. Here are the results of a notch effect of a to-

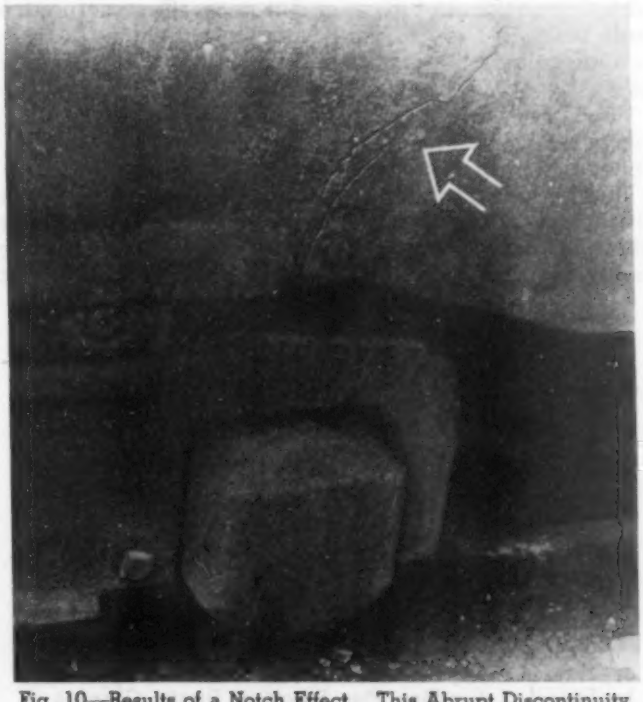


Fig. 10—Results of a Notch Effect. This Abrupt Discontinuity Was Designed Into the Structure

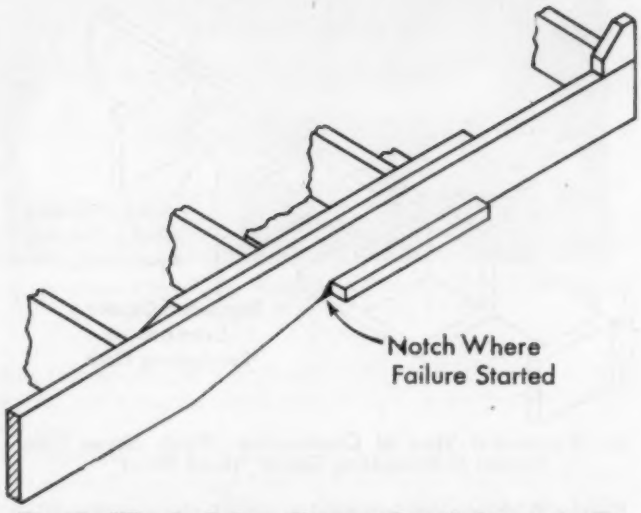


Fig. 11—Why the Failure, Shown in Fig. 10 Occurred. The Fracture Progressed from an Internal Notch at the Root of the Weld, Then Worked up Through the Entire Section

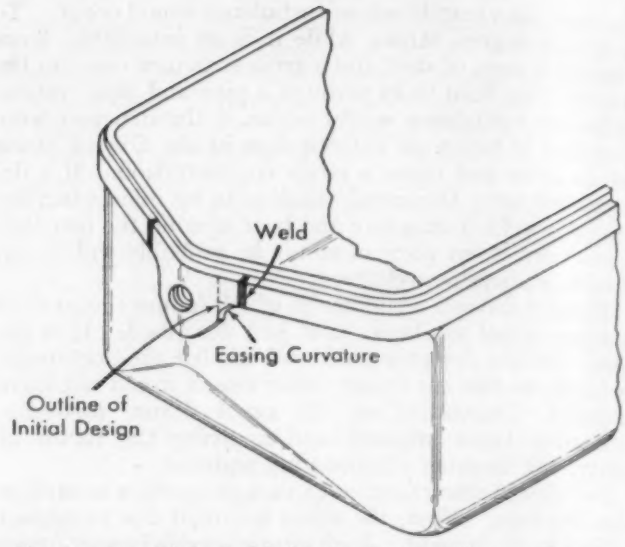


Fig. 13—One Method of Achieving Longer Life in a Charging Box Without Fracture Occurring

tally different type from those previously discussed. The fractures progressed from an internal notch at the root of a chamfered weld. No possible shop control, quality of welding or inspection could eliminate this condition. The notch or abrupt discontinuity actually was designed into the structure.

Figure 11 shows why this failure occurred. The fracture undoubtedly started at the root of this weld. It progressed, probably to the bottom, then worked up through the entire section.

Nothing can eliminate the possibility of failures of this type excepting redesign.

The weak spot could be avoided simply by setting the bottom plates between the primary members. This would eliminate the notching of primary side members.

Many engineers are prone to this kind of designing. Many times, probably more often than not, they "get away" with it. But, here is physical evidence of at least one instance wherein it didn't work. Hence, it is a fair conclusion that when failure does not occur at such a point, two things are true: dynamic loading to an appreciable degree does not exist, or if it does, the structure has not been in service long enough to show distress, a dangerous situation economically; or, the structure is vastly overdesigned.

The "one-horse shay" is still a good goal in engineering, particularly in these days of drastic necessity for minimum weight in many structures.

Figure 12 shows a failure that is due, apparently, to the impact of handling, plus the thermal effects of drastic changes in temperature. The structure is a charging box, or pan, a familiar piece of equipment in steel plants.

Fig. 12—Charging Box, Showing Failure Caused, Apparently, by Impact of Handling Plus Effects of Drastic Changes in Temperature

Its function is that of a receptacle for the elements of open-hearth furnace charges or loads, notably scrap metal.

Charging boxes are loaded with material, handled in various ways throughout the plant and fulfill their final function of being thrust into a furnace of approximately 2800° F., turned over, thus dumping their "charge," and pulled out, empty.

Again, here at the fracture is an abrupt change in metal section. In addition, the root of the weld, by its nature, undoubtedly provides a distinct notch effect.

It must be remembered, too, that nothing in the predictable function of the charging box could foretell failures. No forces in operation conceivably could cause such failure in so far as existing design criteria are concerned. Abuse is possible, but these failures were epidemic. They occurred on several boxes. The thermal effect mentioned is real but it could hardly be predicted accurately.

The designer's responsibility here, therefore, is to feel the necessity (dictated by operating conditions) of eliminating abrupt changes in contours—in the absence of more definite data, to design with the worst in mind.

Figure 13 shows one method of achieving longer life without fracture occurring. This method is a design in which the contour is changed gradually to eliminate the concentration. Only results can prove the efficiency of such a design detail.

The point to be noted here is that such failures can be peculiar to weldments. The nature of foundry processes dictates that changes in section be gradual throughout to assure a good casting.

This can be one reason why designers seemingly continue to ignore the design points that have been cited. They have been trained in the technique of casting design wherein they must observe certain shape rules. Released from this restriction they cannot be blamed for ignoring necessities that are such for totally different reasons.

A mystifying type of failure is that in which a purely secondary member, or its joints, shows distress. The end plate on the engine frame shown in Fig. 14 is in this category. This member is simply a closure plate sealing off certain parts of the mechanism and providing support for auxiliary units. This plate is machined over its entire surface and is drilled and tapped in many places for the support of the blower housing.

The central opening is provided to admit air. In its design a maximum size of opening was desirable.

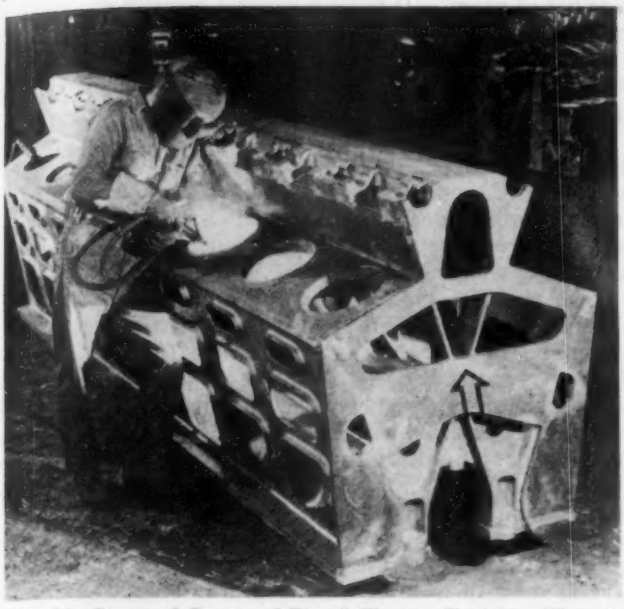


Fig. 14—Repaired Frame of Diesel Electric Engine. Abrupt Changes in Metal Sections or Abrupt Change in Stiffness of the Structure at the Arrow Point Are Eliminated

Figure 15 shows the construction of the frame in the region of this opening. The two slanting inner members carry a primary load to resist the tendency of the firing load to increase the distance between the cylinder head and the main bearings. Thousands of these engine frames were manufactured during a period of several years.

But, in one instance, distress appeared in the fillet weld connecting the end plate with the primary member, at the bottom of the elongated opening. This short fillet weld fractured.

When a failure of this nature happens, with thousands of similar units in service, two worrisome questions naturally occur to the designer: first, can it be an epidemic is started that will culminate in failure of every unit at this point? In other words, is it a fundamental design weakness? Or second, did the unit on which distress first appeared undergo abnormal service conditions?

Fig. 15—End Plate from a Diesel Electric Engine Frame, in Which Distress Shown in Its Secondary Joints Was Eliminated by "Fairing" with Weld Metal

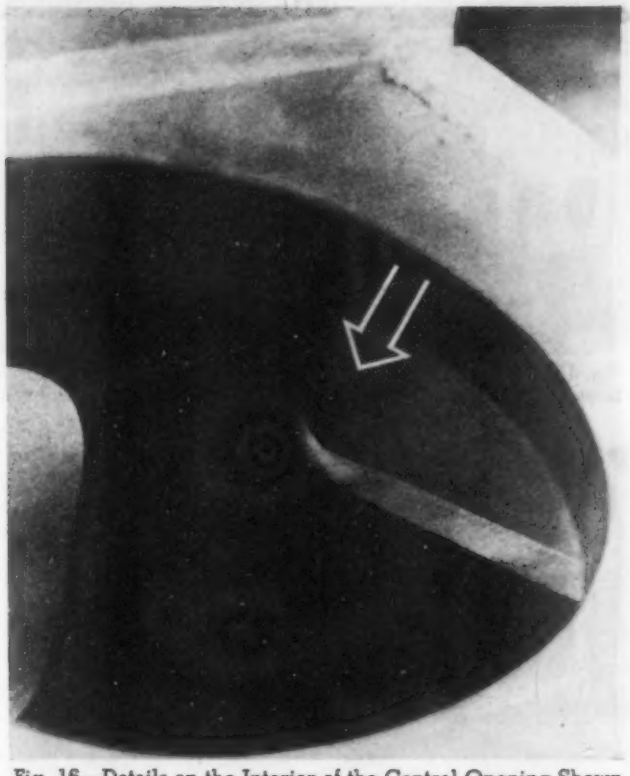


Fig. 16—Details on the Interior of the Central Opening Shown in Fig. 15. Arrow Indicates Where a Gradual Easement of Weld Metal Was Used to Replace a Short Fillet Weld Which Failed

In the instance cited, failure finally evidenced itself on several frames. And, in so far as could be determined, the frames showed no distress at any other location. If the failure were confined to one or two frames, the conclusion might be drawn that the welding was below average standard. There were, however, a sufficient number frames involved here to permit the assumption that the average of quality was involved. These frames were varied in their ages—they were not all produced in one batch that might have been made under similar conditions.

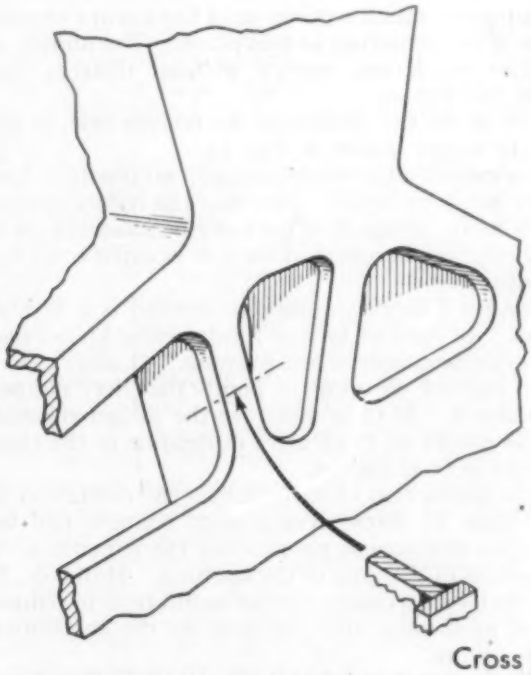


Fig. 17—Abrupt Change Is Avoided at Expense of Slight Reduction in Area of Opening on Diesel Electric Engine Frame

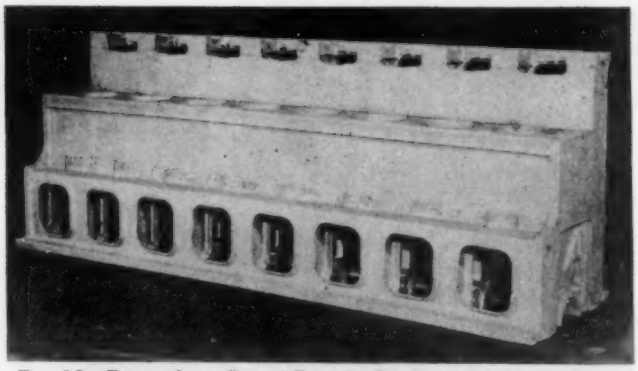


Fig. 18—Frame for a Diesel Engine, Produced in Large Quantities for a Number of Years, and Used Mainly for Auxiliary Power on Shipboard

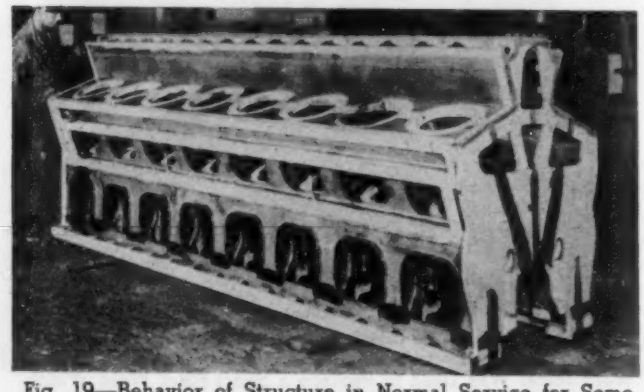


Fig. 19—Behavior of Structure in Normal Service for Some Time, Apparently Subjected Suddenly to Abnormal Forces. Frame of a Diesel Engine of the Type Used for the Propulsion Units of a Submarine

Superficially, this failure might seem of a minor nature. It is to be noted, however, that once the fillet weld in question develops a crack in its surface—a severe notch exists in the edge of a primary member.

The frames involved were repaired in the manner shown in Fig. 15. The defective weld was removed completely and a gradual "easement" or "fairing" was created by weld metal as shown.

Here again the correction is based on the elimination of abrupt changes in metal section, or of the abrupt change in stiffness of the structure at this point. The ability of the structure to absorb energy without distress was changed in this region.

Figure 16 shows the details on the reverse side, or interior, in the region shown in Fig. 15.

All this occurred some two years ago; no report of further failure has been heard. Nor had the failure spread to others of many hundreds of such engine frames in service. Why a failure occurred in the few isolated cases remains unanswered.

That abnormal service conditions existed is a logical assumption. In spite of lack of fundamental knowledge here, the discussion serves one purpose. It shows that unexpected failures do occur at points that defy mathematical analysis. At these points in the design reliance must still be placed on qualitative evaluation of the elastic behaviors of steel shapes.

On future production of such frames the correction is simple. Figure 17 shows how abrupt changes can be avoided in an economical manner, at the expense of a slight reduction in the area of the opening. However, it is obvious that such a design change would tend to reduce the level of maximum stress induced by the conditions causing the failure.

Figure 18 shows a frame for another type of Diesel engine that has been produced in large quantities for a number of years. It is for a general-purpose engine used mainly for auxiliary power on shipboard.

In 1943, failure occurred in this frame of a type which definitely indicated unusual service, something that was practically impossible for the designer to foresee.

Of thousands of frames produced for these engines only approximately 30 showed distress. Thus, the design adequacy of the frame was proved most thoroughly. In further support of this statement is the fact that all failures occurred on engines in a particular type of service on a particular type of ship.

Two things became apparent in the investigation of this failure: first, the nature of the service was such that the engine might be subjected suddenly to peak load conditions at full speed; second, the ship seemed to be of such class and in such service that it rolled and tossed violently. Trouble with foundation bolts bore out these conclusions; in addition, information on the conditions encountered at sea indicated severe inertia forces due to the swaying mass of engine.

In this instance, failure occurred in a secondary member an oil-confining side plate, $^{3}/_{16}$ in. thick, of ordinary carbon steel, of welding quality and not structurally important. The designer had no idea any stress could possibly be induced in this member that would cause its failure.

Fig. 20—Surface of Fracture in a Weld Joining a Secondary Member to Upper Portion of the Engine

Fig. 21—Fracture Through the Parent Metal Adjacent to the Weld. Obviously, It Originated in the Poor Contour at the Edge of the Weld

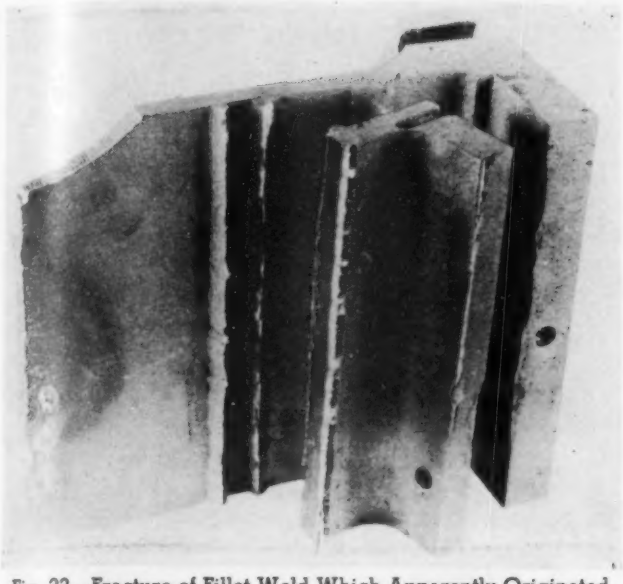


Fig. 22—Fracture of Fillet Weld Which Apparently Originated From Slag Inclusions in the Interior of the Weld

Generally, the fracture started in the extreme lower corners and progressed toward the first or last lower openings to be seen in the illustration. No failure occurred at any other point in the structure. Under abnormal service, failure might be expected to appear in, or adjacent to, a highly loaded member.

One thing is evident from the facts—the distress was related to the hold-down or foundation bolts. Possibly prestress occurred in the fracture region because of the elasticity of the foundation. If sudden and severe peak engine load occurred simultaneously with a violent sea, it is probable that the combination might cause abnormal stress in the region of the foundation bolts. Naturally, the acme of such abnormally high stress would occur at the ends of the frame where the lower portion of the frame is most rigid.

There is where trouble occurred with bolts that tied the engine to its foundation. Apparently, bolts in the lower rail toward the center of the engine were relieved by the flexibility of the frame in this region. In any event, this engine frame has not shown any other weak spot after years of use in various applications. Furthermore, this one type of failure has not evidenced itself, so far as is known, in any but this one type of service.

Thus, with the steelyard car frame and the charging box, we have now seen two types of failures which can be considered as resulting from a lack of attention to design details.

A third instance is the failure of the fillet weld in the opening on the engine frame end plate. This failure is the result of a combination of two factors. On one hand, the design was at fault for the abruptness of change in contour and should have been suspected as a possible trouble point. On the other hand, the design apparently is adequate for most types of operating service, for a very small percentage of engines in service have shown failure at this point.

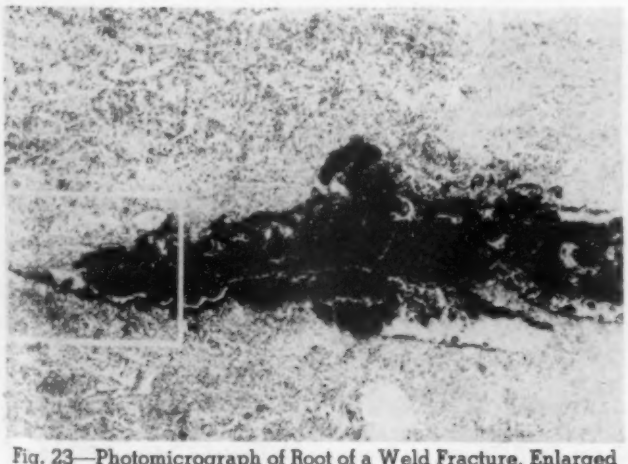


Fig. 23—Photomicrograph of Root of a Weld Fracture, Enlarged 100 Diameters

Here again, a peculiar type of service and apparently not poor design seems to have induced failure in a relatively few frames. The failure, at least, did not occur in a region that might be criticized as being poorly designed.

Figure 19 shows another type of failure that might be considered, involving abnormal conditions. It pictures the behavior of a structure in normal service for a considerable period but apparently suddenly subjected to abnormal forces.

An engine with a frame similar to that shown here was put in service several years ago. Since the engine was operated for about 10,000 hr. as one of the propulsion units of a submarine, it would seem reasonably safe to conclude the design had proved entirely adequate. In addition, innumerable other frames of this type were in similar service.

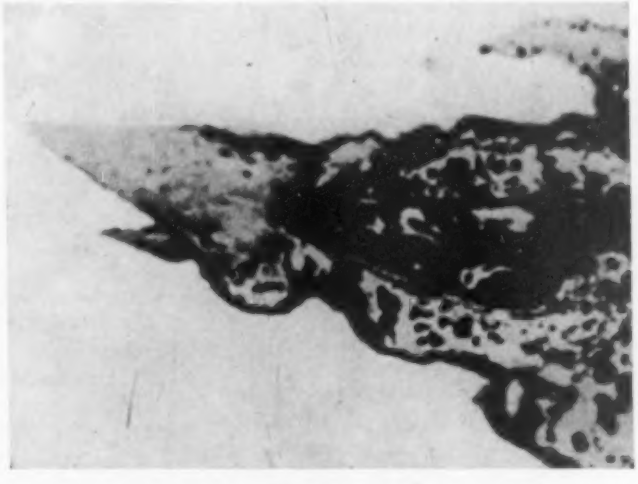


Fig. 24—The Innermost Tip of the Crack Pictured in Fig. 23 at Greater Magnification

During World War II, however, the submarine was depth charged many times, on one occasion so violently that she was blown to the surface. Some time following these experiences fractures were discovered in the engine frame.

Subsequently, this failure was investigated thoroughly, as the result of which 126 cracks were found throughout the frame structure. Many of these fractures started at stress raisers such as machined contours; others started at the edges of openings. Many cracks originated in the welds connecting secondary members in the structure, but none of the fractures occurred in either the welds or the parent metal of primary members.

Figure 20 shows the surface of a fracture in a weld joining a secondary member to the upper portion of the engine. It is apparent that this fracture originated in the interior of the weld, starting from an unfused area and progressing outward toward the surface. The unfused area at which the crack started provided, of course, an internal notch effect.

Figure 21 illustrates another type of fracture in the same secondary member. This crack, through the parent metal adjacent to the weld, obviously originated on the surface at a notch effect induced by poor contour at the edge of the weld.

Figure 22 shows a fracture occurring in a fillet weld

connecting a machined supporting rail to the side of the frame. This crack has certain peculiarities. First, it originated on the surface in the center of the weld, which would seem to indicate that the force initiating the fracture was simply of such magnitude that the fillet wasn't heavy enough. Hence, failure occurred in what might be termed an ideal manner for a fillet weld, from the surface through the throat of the weld. The fillet did not fracture at its edge due to undercutting or overlapping. The fracture did not follow the boundary zone between weld metal and parent metal, as sometimes happens. It is to be noted in the illustration, too, that the crack shown was not continuous. The shiny portions reveal the unfractured area of the weld torn apart in the investigation so that the fractured surfaces could be laid open.

This failure, then, consisted of a series of small cracks on the surface, extending approximately through one-half the throat thickness of the weld. (These cracks can be seen as the dark portions on the surface of the fracture.)

Why wouldn't a fracture, started by an abnormally severe shock, progress continuously, instead of as a series of short cracks separated by narrow widths of unfractured metal and extending inwardly to about the center of the weld?

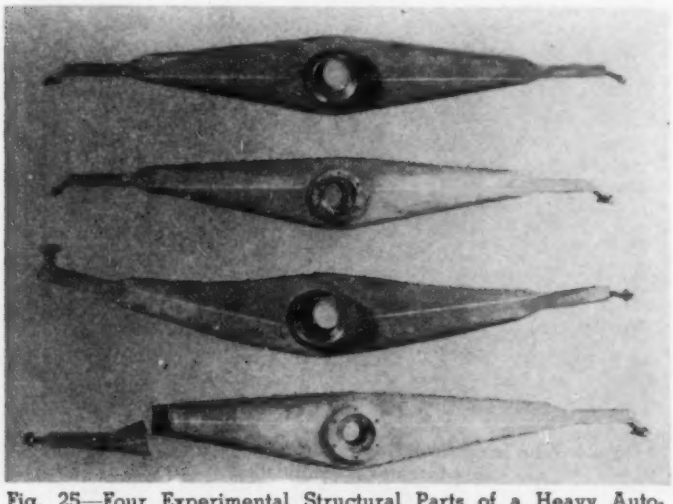


Fig. 25—Four Experimental Structural Parts of a Heavy Automobile Truck, Showing Results of Failures in Two Lower Weldments. No Distress Was Apparent in Two Upper Weldments Pictured Here

That these cracks outlined a weak zone in the weld, undoubtedly caused by slag inclusions, is a logical conclusion. More minute investigation subsequently proved it. Figure 23 is a photomicrograph of the root of one of these fractures enlarged 100 diameters. Figure 24 shows at great magnification the innermost tip of the crack pictured in Fig. 23. It is reasonable to assume from this that slag impurities existed, probably trapped during the finishing beads of the weld.

Fracture possibly was caused by the inertia of the mechanical mass bolted to the rail during severe over-all shock, such as might occur during depth bombing.

The apparent significance of the failure in this engine frame is that the primary member withstood the severe shock. It seems reasonable to assume, therefore, that the design was adequate.

There were no fractures discovered in any member, failure of which possibly would have caused the engine to cease operating. Yet the design was so close to the edge in its economy that many fractures—126 of them—did occur under abnormal shock. It would be difficult to predict the length of time that the engine could continue in operation even though these fractures existed.

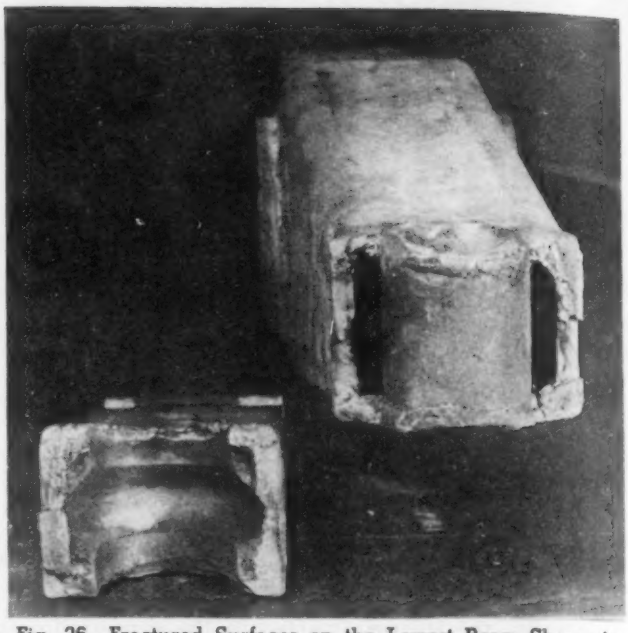


Fig. 26—Fractured Surfaces on the Lowest Beam Shown in Fig. 25, with Fracture Clearly Following a Butt Weld

It is known that the ship traveled many thousands of miles with at least some of these fractures in the frame. But there is no way of knowing to what extent the fractures progressed during this continued operation. This example is a manifestation of the stamina of steel engine frames.

In the early days of World War II, iron frames were found to shatter under such conditions, making operations of engines impossible.

Figure 25 shows four weldments utilizing a relatively high-strength steel. These are experimental structural parts of a very heavy automotive truck. It is fortunate that these parts were experimental, or pilot models, considering what happened to them.

In service, the two weldments shown at the bottom of the illustration operate as simple beams with side thrust imposed in addition to vertical loading. The two beams are positioned one above the other dividing the load.

The sequence of failure is interesting. In the beam at the bottom in the illustration, the left member of it failed completely, the end breaking off as can be seen. The failure occurred because of a defective weld. The failure of this beam threw an abnormal load on the other, the member shown immediately above it in the illustration. The result of this abnormal load can be seen. This second beam failed in bending; a failure of the gross structure.

Fig. 27—Jacketed Type Steel Drier Roll Showing Bulge in Outer Shell Caused by Excessive Hydrostatic Internal Pressure During a Test

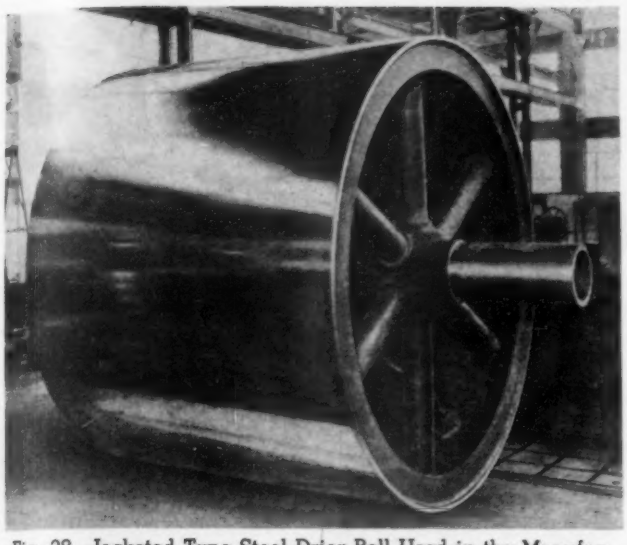


Fig. 28—Jacketed Type Steel Drier Roll Used in the Manufacture of Crepe Papers. This Drier Roll Is 8 Ft. 0 In. O.D. with a 6-Ft. 10-In. Face, and Weighs 17,685 Lb.

It is to be noted that the same welded joint existing in all beams did not fail in spite of the obvious overload on this left beam. It is to be noted also that the two members uppermost in the illustration showed no distress. These beams operate in similar manner on the opposite side of the vehicle.

Conclusions regarding this failure can be illustrated in Fig. 26 which shows the fractured surfaces on the lowest beam, with the fracture clearly following a butt weld.

The end member, or lower piece, was welded to the other portion. This weld was completed and made predictable by utilizing a circular hole in the upper and lower surface. A tubular piece was then inserted in this hole and welded top and bottom. Obviously these closing welds could be made only from one side. If the lower edge of the bottom piece is examined, the causes inducing failure can be determined. It will be noticed that the weld is cracked out almost to the surface, with the fracture area oxidized. This can mean only that the interior of the weld was cracked before the piece was put in service for some time, until the end broke off completely. Seven other points in the structure, designed in exactly the same manner, did not fail. Two such points on the bent beam previously shown did not fail even under such abnormal load.

This is a poor design not because failure occurred at one point out of eight, but because it was at a point which could not be checked by visual inspection. Nor could this weld be inspected conclusively by X-ray because of its design. Hence, such design detail cannot be permitted in quantity production of beams of this nature.

This illustration serves to emphasize the fact that weldments involving high-strength steels are being applied in service where completely predictable joints are demanded. The solution is not to eliminate the welded joint redesign . . . but to change the design so that the quality of joint will be completely predictable.

Figure 27 shows a failure radically different in nature from those that have been considered. This is a polished jacketed-type cylindrical steam drier roll, of a type produced for many processing industries such as papermaking and printing. It is apparent that something went wrong on this roll to distort it. In testing this roll with hydrostatic internal pressure, the pressure accidentally, drastically exceeded that required with the result the outer shell bulged in the manner shown in the illustration. The roll, of course, was useless in such condition and it was necessary to replace the outer shell and remachine it. Figure 28 shows a full view of the roll, giving an idea of its over-all design.

This failure is of interest because previously no one had any idea how this type of weldment would withstand abnormal loads. In this failure, there is reason to believe that maximum pressure inducing failure was several times the design pressure.

Figure 29 shows the construction details of the drier roll and indicates the manner of failure. No fracture occurred anywhere in the structure causing leakage. The one-sided corner welds with notches on their inner sides did not fail. This is to be particularly noted since one would expect distress at the inner notch behind the weld in the upper corner. One might expect this because of the ripping action of the bulge shown on this weld.

Ultimately, of course, something would have opened up but the accidental high pressure was discovered before this could happen.

The main point in discussing this failure is to indicate the proper use of weld details that are unpredictable in other types of services; hence, liable to failure.

In contrast to the dynamically loaded engine frames previously discussed, this drier roll weldment operates under practically static conditions. A weld of this nature is never used in the design of an engine frame.

Such one-sided welds with unfused roots were used in secondary regions in a very early type of engine frame. They failed consistently in all frames produced to this design. It was necessary to revise the design to eliminate them and to repair all frames in the field.

However, there is no reason for any fear regarding the adequacy of such corners welds in drier rolls, for structures with such welds have been in service for many years. But, how such welds would behave under accidental overload remained to be seen. Whether the weld would rip due to its internal notch from the flexure caused by the bulging of the shell is a moot question. In this instance of apparently drastically abnormal pressure no distress occurred in the welds indicated.

One of the reasons for discussing this type of failure is that some designers err in the other direction of too much caution. At times fabricating shops have been furnished blueprints of designs that specify full-strength welds in every joint. If followed to the letter this specification would result in an extremely costly weldment. Few, if any, weldment designs, excluding pressure vessels, require completely full-strength joints at all points. This is not true for all pressure vessels, but only to thick-walled vessels subjected to very high pressures. By "full-

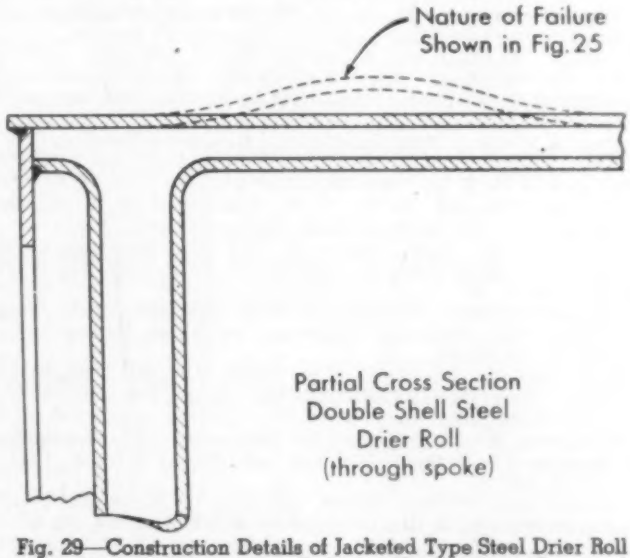


Fig. 29—Construction Details of Jacketed Type Steel Drier Roll Indicating the Manner of Failure. No Fracture Occurred Anywhere in the Structure Causing Leakage

strength weld" is meant one that is fused completely throughout the full metal thickness and subject to meticulous inspection under the usual standards.

From this, it is apparent that it is incumbent upon the designer to follow the "middle of the road" with a true feeling for what a particular joint must withstand.

Much remains to be learned regarding the structural behavior of dynamically loaded fabricated parts. It is true that a fine knowledge of the properties of materials exists. It is true, too, that certain types of welded joints can be evaluated and their quality be controlled. But what happens to such structural properties when materials and joints are disposed in all manner of shapes is not known with any accuracy; especially when dynamic loading is imposed at times on such shapes which might be exposed to violent fluctuation beyond normal stress levels.

On two recent occasions, high-strength steels were used, apparently without recognition of their possibly poor endurance limit when notch effects exist. Recognition of the structural behavior of dynamically loaded structures was not present because a myriad of internal and external notches existed in the design.

Generally, the cost of making full-size experimental stress analysis studies is prohibitive. If the nature of the work justifies experimental stress analysis, it must be remembered that such analysis tells nothing about the life of the structure at such levels.

Much work has been done in developing machines for full-scale fatigue testing. However, the cost of such equipment and the expense of operating it are so high as to limit this field of investigation to companies producing large quantities of the identical product or part. Therefore, designers must continue to grope, using knowledge of material properties established under ideal conditions and continue to apply the factor of safety—or of "ignorance."

Why this method is not sufficient since it has worked for so long is a logical question. Why it is not sufficient may be answered by these two reasons: first, fabricated structures are being designed to operate at increasingly higher stress levels; second, weldments by their nature may contain internal and external notch effects. Elimination of notch effects is entirely prohibitive from the standpoint of cost and of the resulting limitation on design freedom.

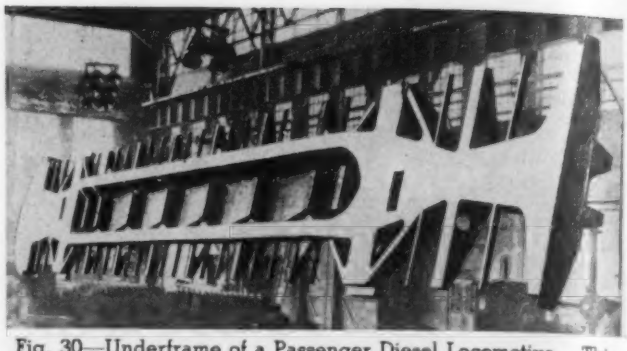


Fig. 30—Underframe of a Passenger Diesel Locomotive. This Under frame 78 Ft. $5^{5}/_{16}$ In. Long by 8 Ft. $11^{1}/_{4}$ In. Wide by 3 Ft. $2^{7}/_{16}$ In. High, Weighs 32% Less than Its Prewar Counterpart. This Design Accomplishment Is Made Possible by a Clinical Study of Weldments

It seems, therefore, that careful, correlated study of failures is the one remaining way of obtaining data of practical value, a recognition of the fact that a failure is an opportunity to learn something rather than an occurence that must be hidden. With such a program it can be said with confidence, basic principles of the behavior of dynamically loaded structures would emerge. Figure 30 shows the underframe of a passenger diesel locomotive of a postwar model. It also represents the tremendous strides taken by the welding industry. This underframe weighs 32% less than its prewar counterpart—a reduction of 13,000 lb. Such a design accomplishment is made possible by a clinical study of weldment failures and by intensive attention to design details—both economic and structural.

(*Continued from page 192*)

Electric Welding Electrodes. How to Select Mild Steel Arc Welding Electrodes, H. O. Westendarp, Jr. Steel Processing, vol. 33, no. 11 (Nov. 1947), pp. 679–680, 703.

Electric Welding Electrodes. Where and How to Use Controlled Hydrogen Electrodes, O. T. Barnett. Industry & Welding, vol. 20, no. 10 (Oct. 1947), pp. 26–29, 74–77.

Electric Welding Machines. Maintenance of Welding Machines, C. A. Lehton and H. F. Worcester. Mill & Factory, vol. 40, no. 6 (June 1947), pp. 114–115.

Electric Welding Machines, Manufacture. Stampings for Welded Fabrication Cut Costs and Increase Production, C. G. Herbruck. Iron Age, vol. 160, no. 24 (Dec. 11, 1947), pp. 102–104.

Electric Welding, Resistance, Sheet Metal. Spotwelding Specialists, T. P. Cullin. Industry & Welding, vol. 20, no. 9 (Sept. 1947), pp. 34–35, 38, 64–65.

Electric Welding, Resistance, Spot. Resistance Welding, C. W. Hinman. Can. Machy., vol. 58, no. 9 (Sept. 1947), pp. 176, 178, 180; no. 10 (Oct.), pp. 148, 150, 152.

Hydrogen-Fluorine Torch, H. F. Priest and A. V. Grosse. Welding Engr., vol. 32, no. 3 (Mar. 1947), pp. 42–43.

Iron Castings. Weld Repair of Grey Iron Castings, C. E. Phillips. Foundry Trade J., vol. 83, no. 1632 (Dec. 11, 1947), pp. 306, 308.

Jigs and Fixtures. Handling in Flow of Production Welding, A. E. Rylander. Industry & Welding, vol. 20, no. 8 (Aug. 1947), pp. 38–39, 58, 60–64.

Light Metals. Development of Strong Aluminum Alloys for Welding. Sheet Metal Industries, vol. 24, no. 248 (Dec. 1947), pp. 2484–2488, 2490.

Manganese Steel. Technique for Welding 11–14% Manganese, R. Bramley. Industry & Welding, vol. 20, no. 9 (Sept. 1947), pp. 40–42, 44.

Metals, Hard Facing. When and How to Mechanize Hard-Facing Operations, E. Hurt. Industry & Welding, vol. 20, no. 8 (Aug. 1947), pp. 30–32, 44, 46; no. 10 (Oct.), pp. 52, 54, 56, 58–59.

Non-Ferrous Metals. Welding of Non-Ferrous Metals, E. G. West. Sheet Metal Industries, vol. 24, no. 237 (Jan. 1947), pp. 167–172; no. 239 (Mar.), pp. 618–622, 624; no. 241 (May), pp. 1017–1023, 1027; no. 243 (July), pp. 1425–1429, 1435; no. 244 (Aug.), pp. 1643–1645; no. 246 (Oct.), pp. 2058–2061.

Oxyacetylene Welding, Fire Prevention. Stop Those Welding and Cutting Fires, G. R. Webster. Industry & Welding, vol. 20, no. 10 (Oct. 1947), pp. 38–39, 44, 46, 90–92; see also, Safety Eng., vol. 94, no. 5 (Nov. 1947), pp. 16, 40.

Oxygen Cutting. Flame Planing Processes, F. A. Westbrook. Mass Production, vol. 23, no. 8 (Aug. 1947), pp. 54–57.

Oxygen Cutting, Stainless Steel. Flame Cutting Stainless, G. E. Bellew. Industry & Welding, vol. 20, no. 12 (Dec. 1947), pp. 30–31, 34.

Pipe Lines. Welded Pipe Fabrication, A. R. Berry. Industry & Welding, vol. 20, no. 6 (June 1947), pp. 46–48, 50; no. 7 (July), pp. 46–48; no. 8 (Aug.), pp. 48, 50, 52.

Pressure Vessels, Design. Stress Investigations of Flat Welded-In Heads, H. M. Spring, Jr. Mech. Eng., vol. 69, no. 11 (Nov. 1947), pp. 948–949.

Rolling Mill Practice, Billet Trimming. Mechanized Scarfing. Steel, vol. 121, no. 26 (Dec. 29, 1947), pp. 74, 76.

Ships, Classification. Work of Ship Classification Societies, J. L. Adam. Engineering, vol. 164, no. 4266 (Oct. 31, 1947), p. 428; no. 4267 (Nov. 7), p. 453; see also, Machy. Market, no. 2451 (Nov. 7, 1947), pp. 487–488.

Stainless Steel. Processing and Fabrication of Stainless Steel Sheet and Plate Products, H. S. Schaufus, W. H. Braun, I. C. Clingen and J. R. Federline. Steel Processing, vol. 33, no. 4 (Apr. 1947), pp. 219–224; no. 11 (Nov.), pp. 681–684, 704.

Steel Hardening, Oxy-Gas Process. Flame Hardening of Armor Plate, E. L. Bartholomew, Jr., M. S. Burton and F. R. Evans. Metal Progress, vol. 52, no. 6 (Dec. 1947), pp. 979–983.

Steel Plates, Metal Clad. Seam Welding Composite Plates, O. R. Carpenter. Steel, vol. 121, no. 25 (Dec. 22, 1947), pp. 64–66, 83–84.

Steel Weldability. Ductility of Steels for Welded Structures, A. B. Kinzel. Metal Progress, vol. 52, no. 5 (Nov. 1947), pp. 795–799; see also, Steel, vol. 121, no. 23 (Dec. 8, 1947), pp. 91–92, 108, 111.

(*Continued on page 224*)

Welding and Fabrication of High-Temperature Alloys*

By C. G. Chisholm†

ONE of the most important research programs of World War II was the development, testing and production of new super-alloys for ultrahigh-temperature service. These alloys were developed primarily for the buckets and blades of aircraft turbosuperchargers and turbojet aircraft engines. Many reports and articles have been written concerning the physical, mechanical and metallurgical properties of a hundred or more of these alloys. Such an atmosphere of mystery and awe has surrounded these wartime secret alloys, that many engineers have considered them as laboratory curiosities rather than practical, versatile materials of construction.

This paper is presented in an effort to bring these alloys within the reach of any industrial, design or welding engineer who is faced with high-temperature problems. It will show that, with proper welding and fabricating techniques, these alloys offer no more problems than are encountered with more common materials of construction.

Many intricate and severely formed parts have been made from these alloys in the aircraft industry, particularly in connection with jet planes. High-temperature strength is important for the blades and disks of the engine, and also, because of weight consideration, for the attendant sheet metal parts such as combustion chamber liners, stator vanes, tail cones and exhaust pipes. "Afterburning," or tail pipe flame, for auxiliary bursts of speed, raises the temperature of the already hot exhaust gas still further, and necessitates high strength of sheet metal parts at even higher temperatures. Even conventional piston type engines, as they become larger and deliver greater volumes of higher temperature exhaust gases indicate the need for alloys of greater strength than stainless steel, the standard material of construction for present-day exhaust collector rings. And now that the properties and fabrication techniques are known, other industrial uses for these super-alloys are coming to the fore.

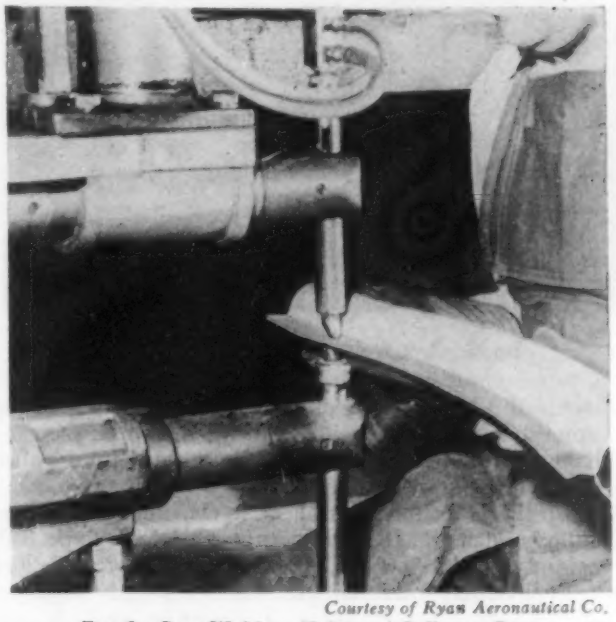
Of the hundred-odd alloys tested in the National Defense Research Program, few are available in commercial quantities; still fewer are available in the form of bar stock, sheet, tubing and wire. This paper will stress some of the few super-alloys that have been produced as sheet metal, because they are the most versatile for design and engineering purposes. These are also produced as castings, forgings and as precision castings (by the "lost wax" process). Further discussions of the chemical, physical and mechanical properties have appeared in several articles in recent technical literature.

These alloys fall naturally into four main groups:

Group A—Cobalt or cobalt-nickel base: Haynes stellite* alloys Nos. 21, 23, 27, 30, 31.

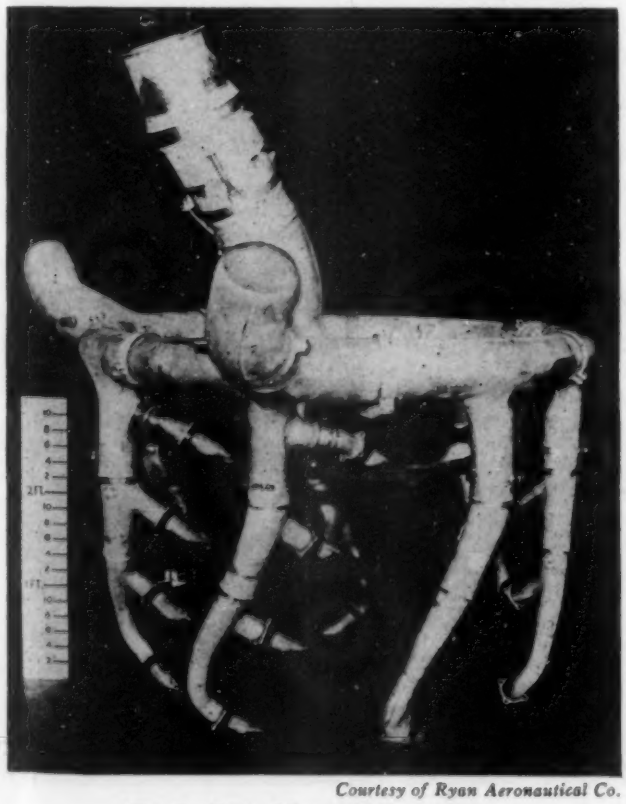
* Presented at 28th Annual Meeting A.W.S. Chicago, week of Oct. 19, 1947.

† Haynes Stellite Co., Kokomo, Ind.



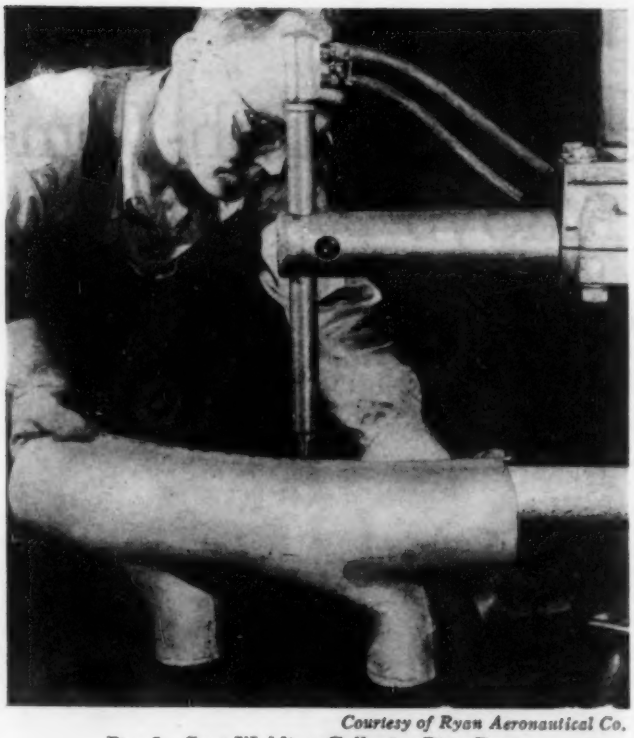
Courtesy of Ryan Aeronautical Co.

Fig. 2—Spot Welding Halves of Collector Ring



Courtesy of Ryan Aeronautical Co.

Fig. 1—Typical Large Collector Ring



Courtesy of Ryan Aeronautical Co.

Fig. 3—Spot Welding Collector Ring Ducts

Group B—Nickel-base alloys containing tungsten or molybdenum: Hastelloy* alloys B and C.

Group C—Cobalt-nickel-iron base: Multimet* alloy (otherwise known as N-155).

Group D—Modified stainless steels, and nickel-base alloys without strengtheners: 18–8 Cb (Type 347) stainless; 18–8 Ti (Type 321) stainless; 25–20–2 (Type 310B) stainless; etc.

The most common method of appraising the inherent high-temperature strength of alloys is the use of high-temperature stress-rupture data for the temperatures in question. Knowing the inadequacy of control of exhaust temperatures, particularly of present-day jet engines, one aircraft company assumed that, because of "hotstarts," any exhaust part occasionally would be heated to at least 1900° F. This company wishes to establish the degree of inherent high-temperature strength of the various alloys available as sheet metal.

* Trade-marks of Haynes Stellite Co.

Courtesy of Ryan Aeronautical Co.

Fig. 4—Melting Down Flange by Fusion Welding

It ran stress-rupture tests at various temperatures after subjecting all the alloys to a 3-min. anneal at 1900° F. Table 1 shows the "Relative Order of Merit" of most of these alloys based on 100-hr. stress-rupture tests after this 1900° F. anneal. Based on these tests, alloys of groups A, B and C have inherent high-temperature strength varying between 175 and 400% of the strengths

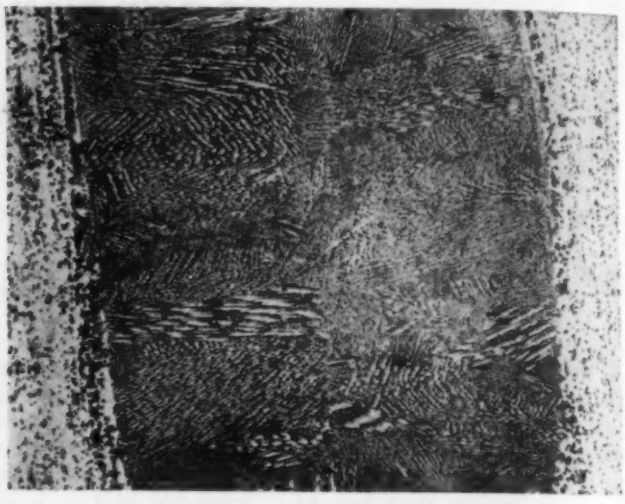


Fig. 5—Transverse Roller Seam Weld, Hastelloy Alloy C. 100 ×

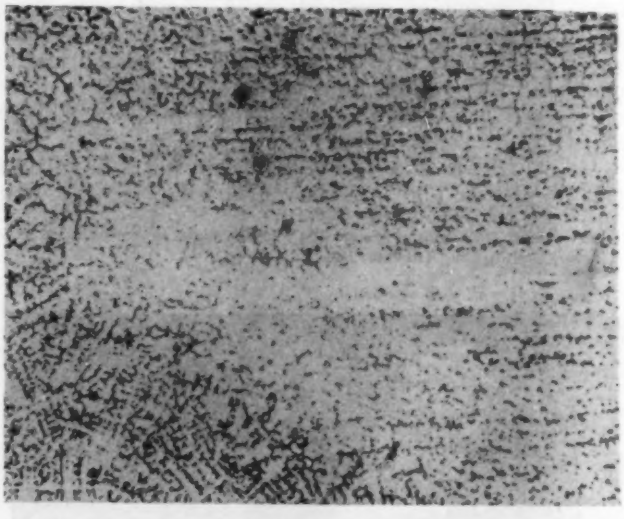


Fig. 6—Oxyacetylene Weld, Haynes Stellite Alloy No. 21. 100 ×

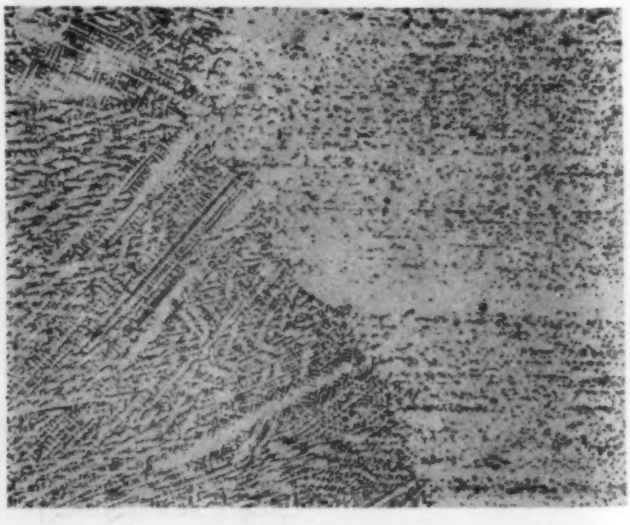
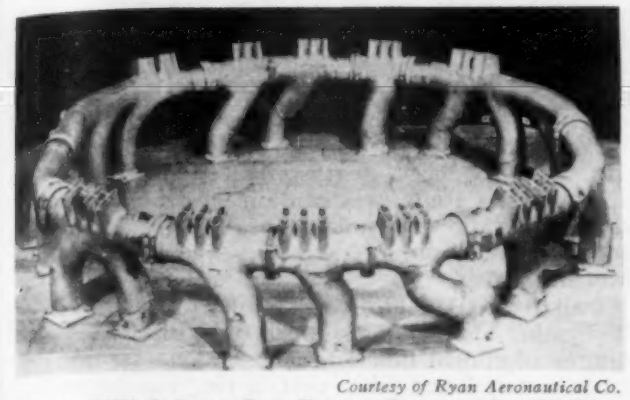


Fig. 7—Oxyacetylene Weld, Hastelloy Alloy C. 100 ×



Courtesy of Ryan Aeronautical Co.

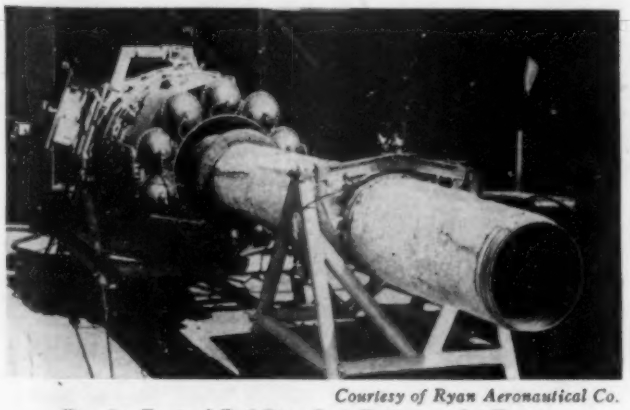
Fig. 8—P2V2 Collector Ring Showing Precision Cast Jet Augmentation Nozzles

of Group D stainless steels and of the alloys containing nickel and chromium without strengthening agents. Some other alloys mentioned in the recent high-temperature literature may have high strengths in the work-hardened or age-hardened condition, but these high values can be lowered drastically by overheating. For other purposes and other temperatures, a somewhat different "Order of Merit" might prevail, based on tests for properties other than *inherent* high-temperature strength, or natural strength even in the fully annealed condition.

This list of alloys in approximately the same order indicates the relative difficulty of forming at room temperature. Those at the bottom of the list, having lower strength, lower hardness and greater ductility, are naturally easier to bend, stretch, press and spin. In general, then, when we consider all the alloys in their fully annealed condition, there is a trend toward higher room temperature strength and lower elongation and ductility, and a greater tendency toward work hardening, in progressing up the list from bottom to top.

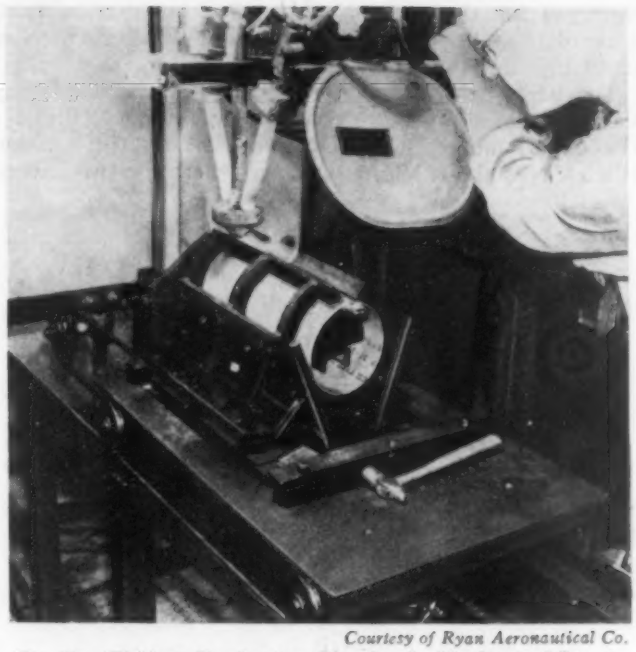
In order to obtain a rough measure of the relative formability of these super-alloys, one of the largest fabricators of exhaust collector rings for aircraft makes a cup by press forming the various alloys. This cup requires 2 draws and 2 anneals when pressed from a flat disk of stainless steel. In 19–9, a higher strength stainless steel, 3 draws and 3 anneals are required. Multimet alloy or Hastelloy alloy C requires 4 draws and 4 anneals. In each instance, the alloys have work hardened during the drawing operation and would tend to crack if drawn further without annealing to regain ductility. Thus, although this company has not tested all of the super-alloys, we would expect Group A to require about 5 or 6 steps, groups B and C to require 4 steps and Group D to require 2 or 3 steps.

The numerous forming and welding techniques that



Courtesy of Ryan Aeronautical Co.

Fig. 9—Typical Tail Pipe Installation on Jet Engine



Courtesy of Ryan Aeronautical Co.

Fig. 10—Welding Combustion Chamber by Mechanical Atomic Hydrogen Welding

are currently used in the manufacture of the aircraft collector ring can be broken down into simple, individual operations. Only slight modifications of stainless steel practices are required for the production of the same parts from the groups A, B and C super-alloys. A discussion of these necessary modifications will be used as an example of recommended methods for the handling of similar types of sheet metal parts. Figure 1 shows a typical large collector ring and illustrates the number of segments that are made separately and assembled to form the finished ring.

The first step in making one of these collector rings is to form halves by stamping flat pieces of sheet metal to shape. These pieces of sheet metal must be of the proper gage and sheared slightly oversize. When halves are made for sections of stainless steel collector rings, the part is stamped to final shape in stages, with one or two intermediate anneals and a final anneal to restore ductility before welding. The same part, made from one of the super-alloys, would require more frequent anneals (as

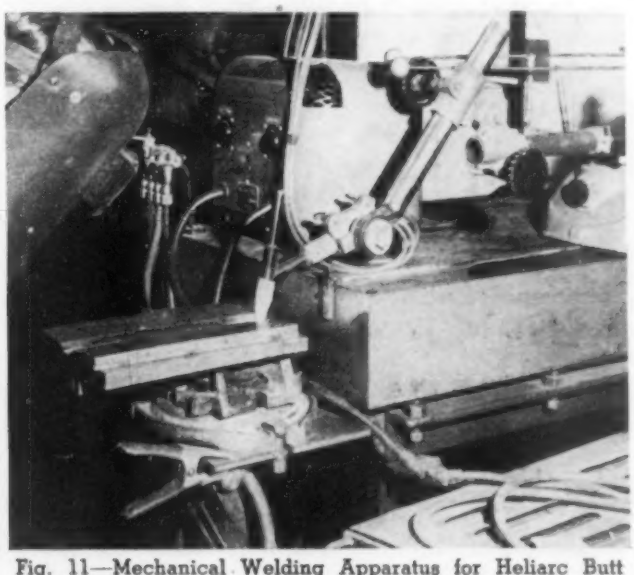


Fig. 11—Mechanical Welding Apparatus for Heliarc Butt Welding of Hastelloy Alloy°C and Multimet Alloy Thin Gage Sheet

indicated for the pressed cup). For instance, a part made of Hastelloy alloy C would probably need twice as many anneals as stainless steel.

The parts are then pickled to remove the annealing scale, and two halves are spot welded together (Fig. 2). The excess metal is then trimmed off by the nibbler which leaves about $^1/_{16}$ in. of flange where the two halves join. The nibbler is also used for cutting off excess metal on flanged halves. This flange is sometimes tacked again by spot welding (Fig. 3), and then it is melted down by fusion welding (Fig. 4). Several such parts are welded together and other fittings, flanges and brackets are welded on to make a finished collector ring.

In order to check joints produced by welding the super-alloys, a study was made of resistance and oxy-acetylene welds. The microphotos (Figs. 5, 6 and 7) show that welds produced by these methods are sound, clean and strong.

Of all the steps in fabricating a collector ring of a super-alloy rather than stainless steel, only the forming step requires additional time and labor. Thus for a slightly higher material and labor cost, a ring can be made of whichever super-alloy gives the best over-all economy. In view of the weight saving made possible by the use of higher strength alloys, and of the lower maintenance and replacement costs of longer-lived collector rings, the experimental rings now being made by at least two suppliers of these parts are of great interest both to the Armed Services and to commercial airlines. This interest will be increasingly apparent as the temperatures and volumes of exhaust gases rise from year to year with the development of more powerful engines.

The collector ring for the "truculent turtle" Lockheed P2V2 (Fig. 8) incorporates the principle of jet augmenta-

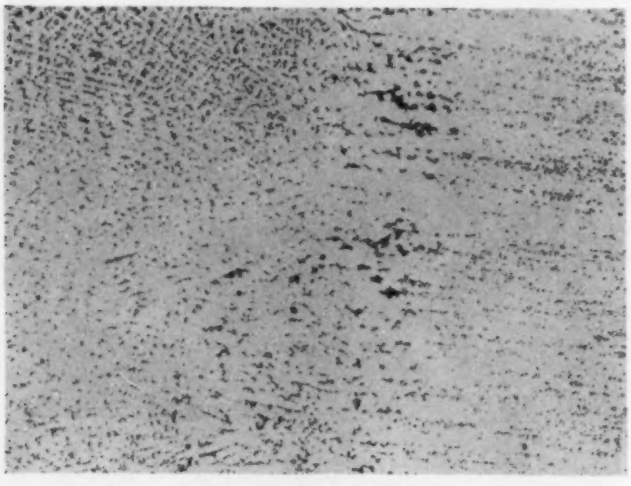


Fig. 12—Mechanized (A.-C.) Heliarc Weld, Hastelloy Alloy C. 100 ×

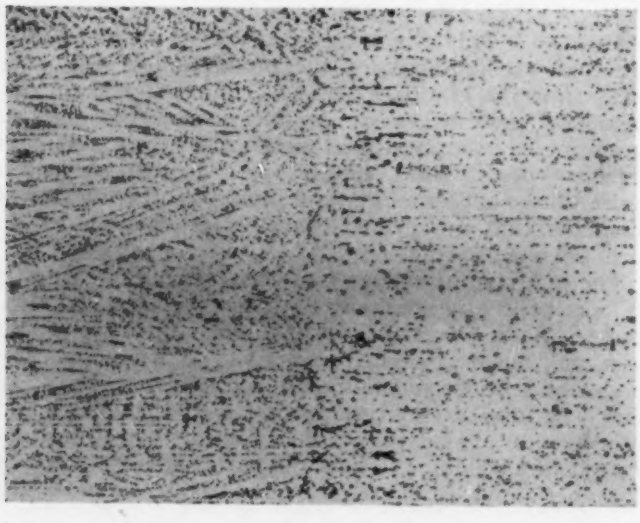


Fig. 13—Mechanized (D.-C.) Heliarc Weld, Hastelloy Alloy C. 100 ×

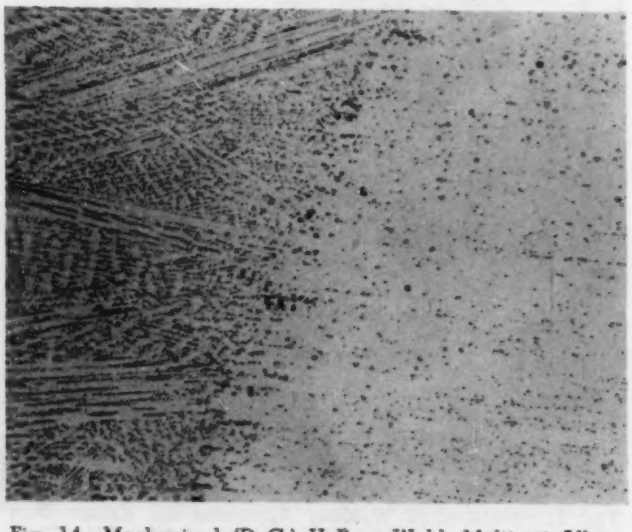


Fig. 14—Mechanized (D.-C.) Heliarc Weld, Multimet Alloy. 100 ×

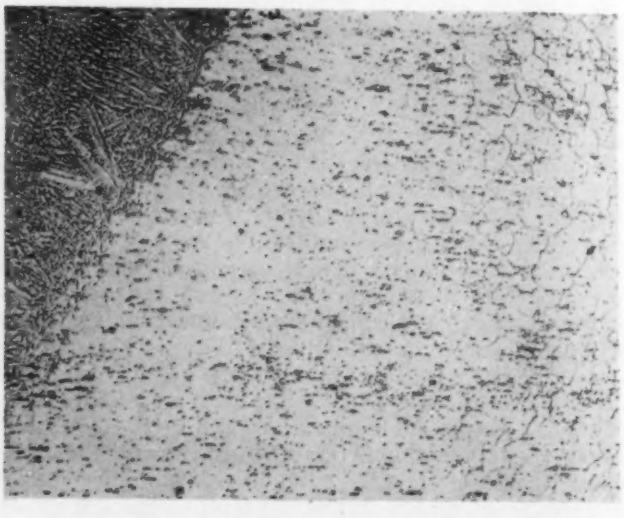


Fig. 15—Mechanized (D.-C.) Heliarc Weld, Haynes Stellite Alloy No. 21. 100 ×

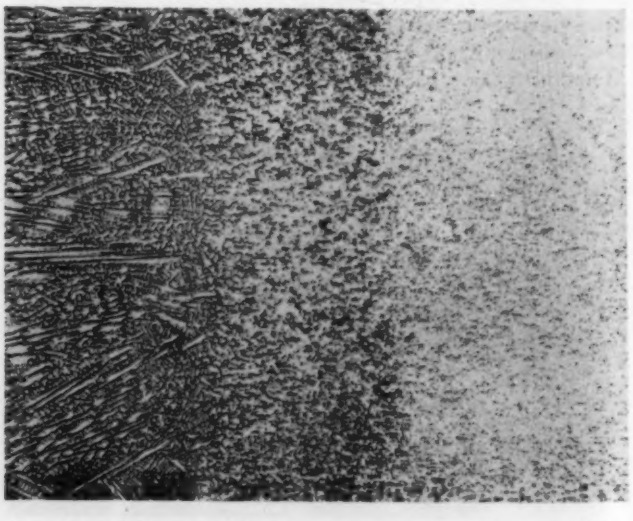


Fig. 16—Mechanized (D.-C.) Heliarc Weld, Haynes Stellite Alloy No. 31. 100 ×

tion, which gained an additional 25 mph. of speed. It will be noted that the jets are individual precision castings welded to the sheet metal manifold. These castings were made in both Hastelloy alloy C and Haynes Stellite alloy No. 21. The precision investment casting ("lost wax") process thus is a useful tool for the manufacturing of intricate parts.

As the operating temperatures of jet engines are increased in order to obtain greater efficiency, it appears that sheet metal alloys higher in strength than the stainless steels may be required for combustion chambers, tail cones and exhaust stacks. Figure 9 shows a typical tail pipe assembly. Many tail cone assemblies of Hastelloy alloy C and Multimet alloy (N-155) have been fabricated by spinning, press and stretch forming, based on modified stainless steel practice.

The super-alloys are readily weldable by all methods applicable to the austenitic stainless steels. However, the alloys are sensitive to heat changes, especially in the range of 1200 to 1800° F. and should be handled by welding techniques which preserve their high-temperature and corrosion properties. Basically, the materials discussed here—Hastelloy alloys B and C, Multimet alloy (N-155), Haynes Steelite alloys Nos. 21, 23, 27, 30 and 31—may be represented as having weldability comparable to the various grades of austenitic stainless steels. These alloys have a coefficient of expansion approximately 50% greater than plain carbon steel and a heat conductivity one-quarter that of plain steel. Their electrical resistivities are higher and their melting points lower than carbon steel. It is evident that all these factors predicate a different welding technique than that used for joining of common steel materials. In this respect, the techniques established for joining the austenitic stainless steels may be used for welding super-alloy materials, with a few exceptions. As with stainless steel, proper care must be taken to prevent distortion and undesirable heat effects. While these alloys are not especially susceptible to precipitation, sufficient care must be taken to confine the heat to minimum areas and to shorten the time at welding heat.

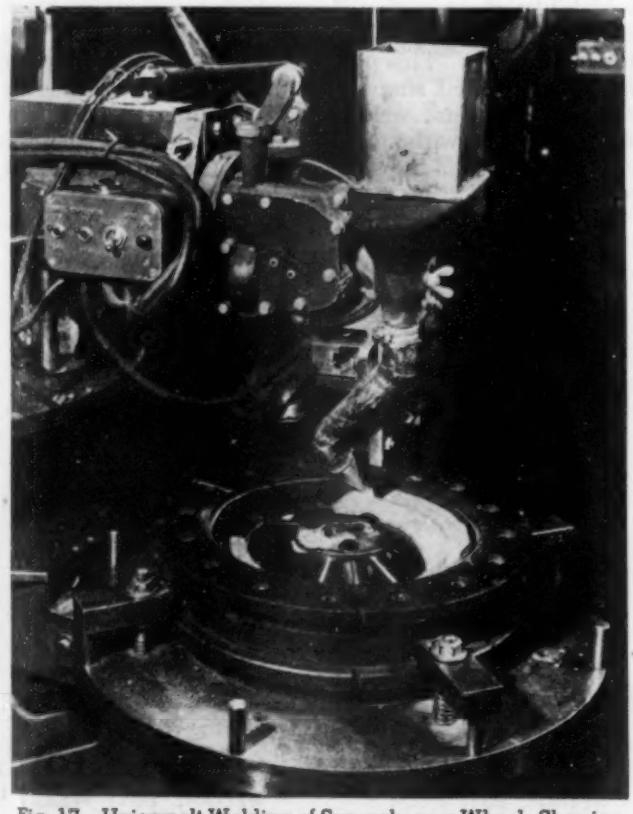


Fig. 17—Unionmelt Welding of Supercharger Wheels Showing Details of Fixtures

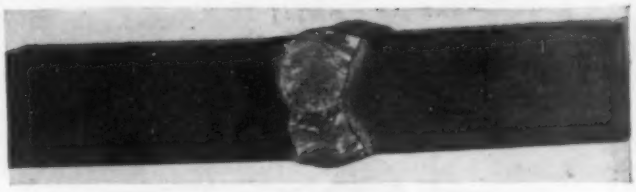


Fig. 18—Test Piece Showing Character of Unionmelt Weld with 19-9 DL Alloy and Haynes Stellite Alloy No. 30

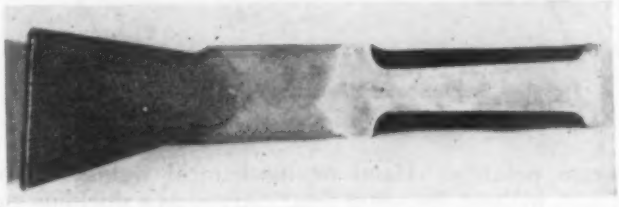


Fig. 19—Unionmelt Weld Showing Section Cut from Supercharger Wheel 16-25-6 Disk, Haynes Stellite Blades Welded with 316 KA 25 MO Rod

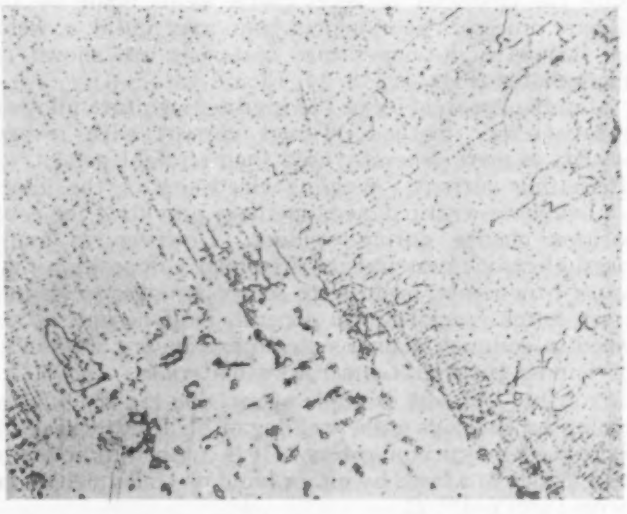


Fig. 20—Unionmelt Weld, Haynes Stellite Alloy No. 21 Blade to 16-25-6 Wheel. 100 ×

The atomic hydrogen process has been used successfully for joining the super-alloy sheet materials. This process produces an intense cone of heat by the arc struck between two tungsten (or carbon) electrodes surrounded by a hydrogen gas envelope. The solidifying weld metal is effectively protected from oxidation by the blanket of hydrogen gas. Figure 10 shows a mechanical setup for welding stainless or super-alloy parts. In the case shown here, a plain butt joint is used, without any welding rod.

The Heliarc* process of The Linde Air Products Co. is one of the most versatile methods of welding sheet metal parts of stainless steel or super-alloys. This method (Fig. 11), sometimes called inert arc- or gas-shielded arc welding, employs a monatomic, inert gas such as argon or helium to prevent oxidation of the weld metal. A single tungsten electrode is usually used, but a carbon electrode may be substituted if proper care is exercised to prevent carbon absorption in the weld metal.

Both a.-c. and d.-c. arcs are used with the Heliarc process, although straight polarity d. c. is preferred for joining the high-temperature materials. When alternating current is used, a high-frequency current is superimposed in order to stabilize the arc and facilitate initial striking. Some difficulty with rectification of the arc may be experienced if a. c. is used, or if d. c. is used with

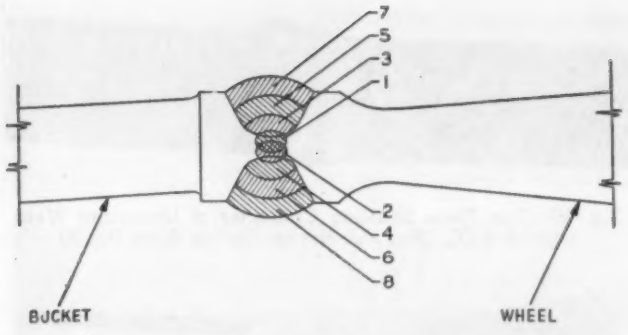


Fig. 21—Sequence of Hand Welding Buckets to Wheel

reverse polarity. Hand or mechanical welds can be secured without the aid of flux. Argon as a shielding gas is preferred since it has a greater stabilizing effect on the arc than helium, especially on thin sheet (24 gage).

A series of photomicrographs were prepared to illustrate the character of sheet metal welds made by the Heliarc process. Sections cut from a.-c. and d.-c. welds on various high-temperature materials are shown on microphotos (Figs. 12, 13, 14, 15 and 16).

Metallic arc welding of the high-temperature alloys is a satisfactory method. Direct current with reverse polarity is more generally used than straight polarity or alternating current. Welding electrodes of the alloys are available with balanced analysis providing for composition change during welding. However, in many cases, electrode materials of dissimilar composition may be used for joints, in order to secure stronger welds and lessen notch cracking. In general, joint designs established in common stainless steel practice are acceptable for joining the high-temperature materials.

Probably the best example of metallic arc welding for joining super-alloys is the welding of blades to wheels on high-speed gas turbine rotors. It is common practice to weld blades to wheels by either hand or Unionmelt (submerged arc) welding.

Unionmelt* welding is a process developed for depositing a bare electrode under a protective layer of special granulated material. The operation is automatic and very fast (Fig. 17). Deep penetration and few passes produce dense, clean, smooth welds (Figs. 18, 19 and 20). A typical example of the speed that can be obtained is shown by the following production weld. On a 12-in. diameter wheel with 144 blades, welding speeds of 18 to 30 in. per minute are possible using current values of 350 to 600 amp., with 30 v. One-eighth-inch diameter electrodes can be used to make one-pass welds on either side of the wheel. Flat base blades with no wheel groove are accepted joint design with the rod deposited angularly into the joint from the wheel side. A small circumferential groove or notch may be machined into the wheel in order to facilitate placement of the rod. The most important factor in producing sound Unionmelt welds is to reduce to a minimum the amount of unfused blade base in the weld area. Blades welded to wheels where the unfused base represents a small area (short of melting into the airfoil section) show the minimum trouble from radial cracking. Unionmelt welding offers promise of being the fastest and most economical way to join blades to wheels in high production.

In hand welding blades to wheels, more passes are required than with Unionmelt welding. A line drawing (Fig. 21) shows the joint design and welding sequence used for typical wheel construction. The following factors are most important in welding blades to wheels: (1) deep root penetration; (2) rapid welding; (3) constant preheat; (4) thorough flux removal between passes.

* Trade-mark of The Linde Air Products Co.

Table 1—Relative Order of Merit of "Superalloys" Based on 100-Hr. Stress-Rupture Data After 1900° F. (3 Min.) Anneal

Alloy	Class	Test Temp. 1200°	1500°	1700°	1900°
HS-21*	A	1	1	1	1
Hastelloy C*	B	2	2	2	3
Multimet (N = 155)*	C	3	3	3	2
18–8 Cb (Type 347)	D	4	5	4	4
25–12 (Type 309)	D	6	7		5
25–20–2 (Type 310)	D	6	4		6
18–8 Ti (Type 321)	D	5	6	5	7

* Supplied by Haynes Stellite Co.

The groups A, B and C super-alloys show excellent resistance to scaling in the oxidizing atmospheres which prevail in most high-temperature applications. Sometimes, however, carburizing conditions are encountered. Accordingly, a study was made of the relative rates of carbon absorption of several alloys by pack carburizing at 1650° F. Photomicrographs indicate that types 321 and 347 stainless steels absorbed carbon into a case layer of about 0.030-in. thickness. In contrast, Hastelloy alloy C and Multimet alloy showed case-hardened layers of only 0.008 and 0.012 in. while Haynes Stellite alloys Nos. 21, 30 and 31 show no evidence of any case-hardened layer. These cobalt-base alloys have outstanding resistance to carbon penetration in this temperature range, while Multimet alloy and Hastelloy alloy C show approximately a 3 to 1 superiority over the stainless steels just mentioned. If this relationship remains the same up to the melting points, it may be assumed that these super-alloys will be less susceptible than stainless steel to carbon pickup during carbonizing welding operations such as oxyacetylene and carbon arc.

A final example indicating both the formability and weldability of one of the Haynes high-temperature alloys is illustrated by Fig. 22 which shows a part made from thin-gage sheet. This part is fabricated by shearing the sheet to a curved shape, welding the ends together by mechanical Heliarc welding and spinning to final form across the weld without intermediate anneal. This is a severe test, both of the formability of the metal and of the weld.

These super-alloys are now available in form of con-

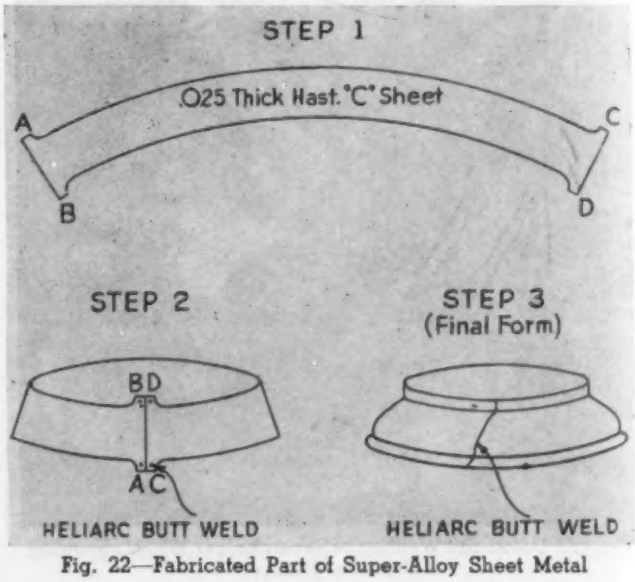


Fig. 22—Fabricated Part of Super-Alloy Sheet Metal

ventional castings, precision investment castings sheet and a wide variety of wrought forms. They may be fabricated by methods discussed in this paper. Therefor it may be concluded that almost any part now fabricated in stainless steels can be duplicated in the superalloys.

French Specifications for Gas Welding Rods

Abstracted by G. E. Claussen*

THE French Committee on Standardization of Welding issued eight preliminary specifications for filler metal for gas welding and surfacing in September 1947. A specification for aluminum welding rods has not been issued but is under consideration.

Gas Welding Rods for Steel

Specification A81-329E classifies nine compositions for welding steel, Table 1. Tests are made for composition and mechanical properties, but no limitations are placed on method of manufacture or weldability.

The tensile strength and notch impact value, according to Specification A81-322E are determined on specimens machined from a pad of weld metal approximately $^3/_4$ in. square deposited on the edge of a mild steel plate 10 in. long, $2^3/_8$ in. wide, $^3/_4$ in. thick. The pad is made in the flat position, Table 2, in 18 to 20 layers each about 0.04 in. thick. The speed of travel of the torch must be about 1.3 in. per minute. The tensile specimen is cut so that the gage length is at least 0.20 in. above the first layer of the pad. The diameter is 0.386 in. The notch impact value is determined on the standard French UF round notch specimen.

The hardness of the weld metal is determined on a pad whose preparation is described in Specification A81-323E. The hardness pad is deposited in 18 to 20 layers each about 0.04 in. thick with a torch travel of about 1.3 in. per minute on a mild steel plate $^3/_4$ in. thick, 4 in. long, $2^3/_8$ in. wide. Table 2 specifies the welding conditions. For Rockwell or Vickers tests the pad is $^3/_8$ in. wide, $1^1/_8$ in. long. For Brinell tests with 10-mm. ball the pad is 2 in. wide, 4 in. long. The pad is machined to within about 0.20 in. of the plate before the hardness test is made. At least three hardness readings are made on the pad.

Table 2—Steel Filler Rod Preparation and Torch Size for Tensile and Impact Pad

Diameter of Filler Rod, In.	Preparation of Rod	Torch Size, Cu. Ft. of Acetylene per Hour
0.047	10 wires twisted or tied together	14–22
0.063 ($^1/_{16}$)	8 wires twisted or tied together	14–22
0.079 ($^5/_{64}$)	5 wires twisted or tied together	14–22
0.098 ($^3/_{32}$)	3 wires twisted or tied together	14–22
$^1/_8$	2 wires twisted or tied together	14–22
$^5/_{32}$ and $^3/_{16}$	A single rod	14–22
$^1/_4$ to $^5/_8$	A single rod	22–28

Gas Welding Rods for Cast Iron

Specification A81-339E applies to the principal type of filler rod for gray cast iron and is not concerned with malleable cast iron, which is best brazed, nor with rods for special types of hard cast irons. The test specimen consists of a butt weld $3^1/_8$ in. long made in two plates of ordinary gray cast iron each $^3/_8$ in. thick and $1^1/_2$ in. wide. The edges are beveled 45°. The plates are supported at their ends on bricks and the weld is made in the flat position with a torch using about 35 cu. ft. acetylene per hour. The flame is perfectly neutral and the blue tip is held 0.20 in. away from the puddle. The weld is built up to two-thirds plate thickness to force fracture in the weld. The flux recommended by the manufacturer of the filler rod must be used.

After being welded, the specimen is cooled in still air and is broken through the center of the weld. To estimate porosity a tracing paper with 1 mm. squares is placed over the two fractured surfaces. No defect over 5 squares in area is allowable. Furthermore no hard white grains or areas in the fracture are allowable. The fractured surfaces must be soft to an ordinary file. At least three hardness readings are made, uniformly spaced on the fracture. The hardness must lie between 240 and 260 Brinell.

Filler Rods for Brazing

By brazing is understood the process of joining with a torch the edges without fusing them and by means of a filler rod quite different in composition from the pieces

* Chief Metallurgist, Reid-Avery Co., Dundalk, Baltimore, Md.

Table 1—Standard French Rods for Gas Welding Steel

Grade	Chemical Composition*	Tensile Strength, Psi.	Elongation % in $2^3/_4$ In.	Notch Impact Value, Meter-Kilograms per Sq. Cm.	Brinell Hardness
A40	.....	50,000–64,000	20	6	100
A50	.....	64,000–78,000	14	5	120
A60	.....	78,000–85,000	10	4	140
A70	.....	85,000 Min.	5	2	220
ACu40	0.5 % Copper ± 0.1%	50,000–64,000	20	6	100
ACu50	0.5% Copper ± 0.1%	64,000–78,000	14	5	120
ACu60	0.5% Copper ± 0.1%	78,000–85,000	10	4	140
ACn	18% Chromium ± 1% 8% Nickel ± 1% Not over 0.10% carbon	Not specified	Not specified	Not specified	Not specified
AC	13% chromium ± 1% Not over 0.15% carbon	Not specified	Not specified	Not specified	400 to 500

* Sulfur and phosphorus each not over 0.04%; the sum of sulfur and phosphorus not over 0.07%.

to be joined. Brazing is used to repair cast iron and bronze, and to join structural steel, light copper, heavy brass, aluminum bronze, etc.

Specification A81-349E describes two types of brazing rods, Table 3. The fusion temperature, determined by means of a thermocouple, must lie between 850–900° C. for ordinary rods and 900–950° C. for high-tensile rods. An all-weld-metal tensile bar is prepared in the same way as in Specification A81-329 except that a torch using 10½ cu. ft. acetylene per hour is employed and the deposit is made 12 to 15 layers. For rods up to 5/64 in. diam., three rods are twisted or tied together for the brazing operation. For 1/8-in. rods, two are twisted together, while for larger rods a single rod is used to deposit the test metal. The flux recommended by the manufacturer is used.

Table 3—Standard Brazing Rods

Designation	Tensile Strength of Deposit, Psi.	Elongation % in 2¾ In.	Bond Strength, Psi.
SB courante (ordinary)	43,000	10	36,000
SB Haute résistance (high-tensile)	50,000	10	50,000

The specimen for bond strength is made of two plates of mild steel butted together, each 8 in. square, 3/8 in. thick in the flat position in two layers. It is not allowed to use the end of the filler rod to scrape the edges to be joined. The torch delivers 8 cu. ft. acetylene per hour for rods up to 5/32 in. diam., and 12½ cu. ft. acetylene per hour for larger rods. The finished joint is cut into strips each 1 3/16 in. wide machined flush. Fracture in tension occurs at the junction between filler metal and plate. Bond strength equals maximum load divided by width times thickness of plate.

Gas Welding Rods for Copper

The success of copper welding depends more on technique and on weldability of base metal than on the filler rod. The base metal should be deoxidized to avoid fusion zone weakness. The filler rod also may be deoxidized copper or may be copper containing small percentages of alloying elements to improve the mechanical properties or to facilitate welding. The properties required in this specification are determined in the as-welded condition, and do not represent the properties obtained in industry where peening and heat treatment are commonly applied.

Specification A81-359E defines two types of filler rods, Table 4. The specimen for tensile strength of all-weld-metal is deposited in 8 to 10 layers in a plate of weldable copper, 1/8 in. thick, 8 in. long and bent to form a trough about 1 3/16 in. high. The torch capacity is 25 to 28 cu. ft. acetylene per hour and the travel speed is about 2.6 in. per minute. A tensile bar, 0.386 in. diam, 2¾ in. gage length, is machined from the deposit. A single rod is used for welding for rods 3/16 in. diam. and larger. Smaller rods are twisted or tied together as follows: two for 5/32 in. diam., three for 1/8 in. and six for 5/64 in. and smaller. Porosity is estimated during machining with the aid of a tracing paper with 1 mm. squares. No defect (blow hole) over 5 squares in area is allowable.

Table 4—Filler Rods for Torch Welding Copper

Designation	Tensile Strength, Psi.	Elongation, %	Alloying Elements
Ordinary	17,000	12	None
Special	25,600	20	Present

Gas Welding Rods for Brass

Specification A81-369E applies to rods, Table 5, for welding two grades of brass only, namely 67% Cu–33% Zn and 60% Cu–40% Zn. Brass welding requires rigorous control of the operation. The base metal must have good weldability, an oxidizing flame must be used with a good flux, and the filler rod must be of the same type as base metal. This specification calls for chemical analysis only. Mechanical properties are not specified.

Chemical analysis is performed on a pad ¾ x 1½ in., 3/8 in. thick deposited on a plate of Type 1 brass 1/8 to 3/16 in. thick, 2⅜ x 4 in. The pad is made in 10 to 15 layers with a torch having a capacity of 10½ cu. ft. acetylene per hour. The ratio of oxygen to acetylene consumption must be 2 to 2½ to 1. The speed of travel of the torch is 2 in. per minute. The flux prescribed by the manufacturer of the filler rod must be used and the drillings for analysis must be taken from the upper part of the pad at least 1/4 in. from the surface of the plate. At least 20 gm. of drillings are collected.

Table 5—Gas Welding Rods for Brass

Designation	Zinc Content, %	Copper Content, %	Lead	Impurities
Type 1	65 to 70	30 to 35	Trace, max.	Not over 0.5%
Type 2	58 to 62	38 to 42	.....	.....

In the above specification the possible use of flux-coated filler rods is foreseen. Length and concentricity requirements for these rods are given in Specification A81-324E.

(*Continued from page 216*)

Sugar Cane Milling. "Spotting" Mill Rollers with Electric Arc for Their Roughening, W. S. Coates. Int. Sugar J., vol. 49, no. 588 (Dec. 1947), pp. 322–323.

Tanks, Welded Steel. Automatic Welding Speeds Tank Production. Industry & Welding, vol. 20, no. 9 (Sept. 1947), pp. 26–29.

Tool Steel. Practical Applications of Tool Steel Welding, N. Anderson. Industry & Welding, vol. 20, no. 11 (Nov. 1947), pp. 30–32, 59–61.

Water Tanks and Towers. Welded Steel, 40,000-Gallon "Golf Ball" Rests on 65-Ft "Tee." Civ. Eng. (N. Y.), vol. 17, no. 12 (Dec. 1947), pp. 44–45.

Welded Steel Structures. Clinical Approach to Weldment Design, G. von Stroh. Am. Soc. Mech. Engrs.—Advance Paper, no. 47, A-132 (for meeting, Dec. 1–5, 1947), 12 pp.

Welders, Training. Education for Welding Personnel, W. J. Brooking. Welding Engr., vol. 32, no. 9 (Sept. 1947), pp. 51–53; no. 10 (Oct.), pp. 64–66, 68.

Welding. Recent Trends in Structural Welding, O. Bondy. Structural Engr., vol. 25, no. 11 (Nov. 1947), pp. 462–481.

Welds, Defects. Caustic Cracking of Welded Steel Plate, H. M. Wilten. Metal Progress, vol. 52, no. 5 (Nov. 1947), pp. 803–805.

Welds, Inspection. Spot-Weld Examination, A. M. Armour. Mass Production, vol. 23, no. 9 (Sept. 1947), pp. 50–54.

Welds, Testing. Spot-Welded Aluminum Components Designed for Repeated Loads, R. C. McMaster and H. J. Grover. Product Eng., vol. 18, no. 12 (Dec. 1947), pp. 158–161.

Welds, X-Ray Analysis. Defects and Preventives in Weld Radiographs, L. Mullins. Iron Age, vol. 161, no. 3 (Jan. 15, 1948), p. 73.

THE AMERICAN WELDING SOCIETY

ACTIVITIES—RELATED EVENTS

STANDARD RULES FOR FIELD WELDING OF STEEL STORAGE TANKS

The sixty-four dollar question asked of those in industry today is: Are you up to date? The technical committees of the AMERICAN WELDING SOCIETY, which prepare Codes and Specifications for industry, have been constantly at work on the answer to this query. A typical example of this is the 1947 Standard Rules for Field Welding of Steel Storage Tanks which has just been issued.

The 1940 edition of the Rules has been in need of revision due to the increased welding of sections above the $1^1/_2$ in. maximum thickness specified at that time. Accordingly, the maximum thickness has been extended to 2 in. and provisions have been made for preheating and interpass temperature control of material thicker than 1 in. In addition, the section on materials of the new edition has been revised in accordance with recent changes adopted by A.S.T.M., and includes those materials commonly used for the fabrication of welded steel storage tanks. Several revisions have also been adopted clarifying the requirements for inspection of shell joints by sectioning methods.

The general arrangement of the Rules has been changed so that reading of tables and certain paragraphs is no longer an arduous task, but can now be easily accomplished and readily understood. The addition of a table of contents to the new issue of the Rules also facilitates more efficient use of them.

Those who are familiar with the 1940 issue of this standard will recall that it applies to the construction of arc- and gas-welded bulk storage tanks of the above-ground type for storing liquid products at substantially atmospheric pressure. The Rules are intended to prescribe safe and proper welding requirements for such tanks and apply particularly to cylindrical tanks with vertical axes and to elevated tanks, all of such diameters that they cannot be shop constructed or shipped by car or truck. These Rules form the basis of Specifications for Water Tanks under the American Water Works Association, Oil Storage Tanks under the American Petroleum Institute and Railroad Storage under the Association of American Railroads, among others.

Some topic included in the new issue are: materials, qualification of welding operators and procedures, joint design details of welding procedure, inspection, testing and repairs. Also included is an appendix covering references to the unit stresses and other requirements applicable to different industries. All concerned with steel storage tanks will want to have the 1947 Standard available for handy reference.

Copies of the 1947 Standard Rules for Field Welding of Steel Storage Tanks, which is priced at fifty cents per copy, can be obtained from SOCIETY Headquarters. The usual discounts to members on individual copies will apply.

PROPOSED AMENDMENTS TO BY-LAWS OF THE AMERICAN WELDING SOCIETY

Approved by the Board of Directors, Buffalo, Feb. 26th

Article I

Section 2: "Qualifications and Privileges." Change "(A) Sustaining Members" to read: "A Sustaining Member shall be an individual interested in the art and science of welding and allied processes, with rights of full membership. A Sustaining Member may be an individual in his own right, or may be an individual designated by a Corporation, Firm or Partnership."

Change "(B) Members" to read: "A Member shall be an individual not less than 27 years of age, who shall have been for at least five years in responsible charge of work having a direct bearing on the art or science of welding and allied processes. Two (2) years' credit may be allowed for graduation from an engineering school. Those in the Member grade shall have rights of full membership."

Article II—Election of Members

It is proposed that the last sentence of Section 1 be removed and that it be set up as a new Section 1, by itself, with the balance of present Section 1, as is, appearing as Section 2, and all following Sections be renumbered, maintaining their present order:

Section 1: "Approval of Membership Applications. All applications for membership shall be approved by the Committee on Admissions."

Section 2: "Sustaining Members, Members and Associate Members." (Same as present Section 1, except that the last sentence is omitted.)

Section 3: Section 2, "Honorary Members," to be renumbered as Section 3.

Section 4: Section 3, "Student Members," to be renumbered as Section 4.

Article IV—Dues and Fees

Section 1: "Amount of Dues." Change to read:

"The Annual Dues shall be as follows:

(A)	Sustaining Members.	$150.00
(B)	Members.....	18.00
(C)	Associate Members..	13.00
(D)	Student Members...	3.00
(E)	Honorary Members..	None"

Rulings of the Board of Directors adopted February 26, 1948

Sustaining Member—Receive free the JOURNAL, the Year Book, the Handbook, Certificate, name listing in alphabetical and geographical section of Year Book, and name listing under "Sustaining Members" special heading in Year Book, including advertising copy. SOCIETY's other publications at a discount from published list prices.

Member—Receive free the JOURNAL, the Year Book *upon request*, the Handbook to all who are enrolled as Members up to December 31, 1948, and name listing in alphabetical and geographical sections of Year Book. SOCIETY's other publications at a discount from published list prices.

Associate Member—Receive free the JOURNAL, the Year Book *upon request*, and name listing in alphabetical and geographical sections of Year Book. SOCIETY's publications at a discount from published list prices.

Student Member—Receive free the JOURNAL, and name listing in alphabetical and geographical sections of Year Book. SOCIETY's publications at a discount from published list prices.

Honorary Member—Same as "Member."

A Company that pays $100.00 or over for members enrolled in the Member and Associate Member grades will have the Company name and address listed separately in the Year Book.

Certificates: Sold at published price to all except Sustaining and Honorary Members.

Article VIII—Officers and Terms of Office

Section 1: Add "an Executive Secretary" between "District Vice-Presidents" and "Secretary."

Section 8: (New) "Executive Secretary. An Executive Secretary shall be appointed by the Board of Directors for a term of one year."

Change present Sections 8, 9 and 10 to 9, 10, and 11, respectively.

Article X—Management

Section 7: (New) "Duties of Executive Secretary.

"(*a*) The Executive Secretary shall be, under the direction of the President and the Board of Directors, the Chief Executive Officer of the SOCIETY.

"(*b*) He shall be ex-officio a member of all committees, except the Executive, Finance, Admissions, Nominating, Constitution and By-Laws, Code of Principles of Conduct, Awards, Honorary Membership and Honorary Directorship, Permanent Funds and Special Committees unless so ordered by the Board of Directors.

"(*c*) He shall engage such employees as may be authorized by the Board of Directors and shall manage all activities of staff officers and employees.

"(*d*) He shall supervise and promote the affairs of the SOCIETY nationally and internationally, under the direction of the President and the Board of Directors.

"(*e*) He shall visit all Sections in the continental United States at least once each year, if at all practicable, and shall supervise the organizations of new Sections where the need, the potential and the possibility are evident.

"(*f*) He shall submit progress reports of his executive operations to the President and the Board of Directors at the periodical meetings of the Board during the year, and a complete report for the fiscal year at the last regular meeting of the Board preceding the annual meeting, and to the members at the annual meeting.

"(*g*) He shall devote the entire time of employment to the affairs of the SOCIETY unless otherwise authorized by the Board of Directors.

"(*h*) He shall perform all other duties which may, from time to time, be assigned by the Board of Directors."

Renumber Section 7 as Section 8.

Section 8: "Duties of Secretary"

Delete present Paragraphs (*a*) and (*c*) and reletter (*b*) as (*a*) and revise to read.

"(*a*) The Secretary shall attend all meetings of the SOCIETY, of the Board of Directors and of the Executive Committee; prepare the business therefor, and duly record the proceedings thereof.

Reletter (*d*) as (*b*), (*e*) as (*c*,) (*f*) as (*d*), (*g*) as (*e*), (*h*) as (*f*), and (*i*) becomes (*g*) reading as follows:

"The Secretary, under the direction of the Executive Secretary, shall, in his absence be responsible for the direction of the staff officers and employees."

Reletter (*j*) as (*h*), (*k*) as (*i*) and (*l*) as (*j*).

Renumber Sections 8, 9 and 10 as 9, 10 and 11, respectively.

Article XII—Committees

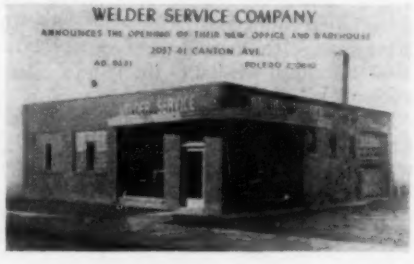
Section 1: "Executive Committee. An Executive Committee consisting of not less than five members of the Board of Directors, shall exercise, at times when the Board of Directors is not in session, such part of the authority of the Board in the administration of the affairs of the SOCIETY, as may from time to time be delegated to it by the Board of Directors."

Rulings Adopted by the Board of Directors

Delete ruling "Attendance at Board Meetings" dated June 28, 1945.

KINZEL MADE PRESIDENT OF CARBIDE LABS.

W. J. Priestley, Chairman of the Board of Union Carbide and Carbon Research Laboratories, Inc., announced the election of Dr. A. B. Kinzel as President of the Laboratories at a meeting of the Board of Directors held on Feb. 5, 1948.



OBITUARY

Clifford B. LePage

Clifford B. LePage, for 30 years assistant secretary of the American Society of Mechanical Engineers, died suddenly of coronary thrombosis in Hartford, Conn., on January 15th at the age of sixty-eight. Mr. LePage lived at Forest Hills, N. Y., but had gone to Hartford to attend a meeting of the American Standards Association.

He was born in 1880 in New York City, and obtained the degree of Master of Engineering from Stevens Institute of Technology in 1902. Starting work as a draftsman in New York, he later became engineer and designer for the United Telpherage Co. of New York. From 1903 to 1921 he was first instructor and then assistant professor of physics at Stevens Institute. He became assistant secretary of the Society of Mechanical Engineers in 1918, and was secretary of its standing committees on research, standardization, power test codes and safety. Mr. LePage was a member of many other technical and scientific organizations.

He is survived by his wife, two brothers and a sister.

* * *

Louis G. Vock

Following an illness of several weeks, Lou Vock, of the Metal & Thermit Chicago office, died on January 26th at Wesley Memorial Hospital.

A native of Chicago, he attended Calumet High School there. Prior to joining Metal & Thermit in November 1922, he had been employed by the Belt Railway in Clearing and during World War I was Foreman Machinist at the Norfolk Navy Yard, Norfolk, Va.

After a short time as a Thermit welder he was made a sales engineer and over the years made many friends in his contacts with the iron and steel industry, the railroads and in heavy industrial plants throughout the midwestern and southwestern states. In 1945 he was appointed District Engineer of the company's Thermit welding department and in October 1947 became Acting Manager of the Chicago district office.

Mr. Vock was a member of the AMERICAN WELDING SOCIETY and of The Fusioneers.

* * *

Henry A. Kelley

Henry A. Kelley, employed by City Pattern Foundry & Machine Co. since Nov. 20, 1924, died on Dec. 16, 1947. He was employed by this Company as Sales Manager for over 23 years and was well known and respected throughout the Foundry and automobile industry.

Mr. Kelley was born in Pawtucket, R. I., July 1, 1884. He was a graduate of the Brown & Sharpe Engineering School and was employed by the General Motors Corp. for five years previous to joining the staff of The City Pattern Foundry & Machine Co.

Mr. Kelley was a member of the AMERICAN WELDING SOCIETY.

* * *

Harry W. Reade

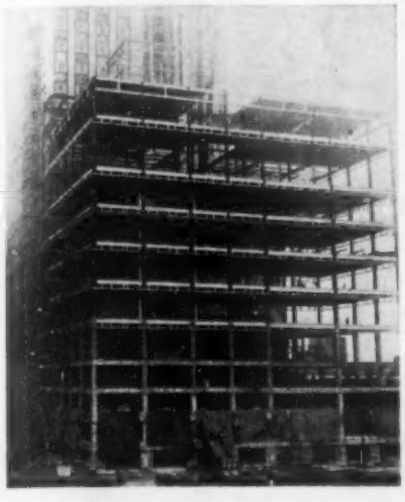
Harry W. Reade, 333 Fairmount Ave., Jersey City, N. J., died suddenly at Jersey City, Sunday, Feb. 15, 1948. He was born at Balston Spa, N. Y., Nov. 26, 1891. He settled in Jersey City thirty-four years ago, at which time he started his business career with the old Davis-Bournonville Co., leading manufacturer of oxyacetylene welding and cutting equipment. On the acquisition of this company by the Air Reduction Sales Co. he became Assistant Manager of the Apparatus Sales Division. During his thirty-three years of continuous service with the Air Reduction Sales Co., he held responsible managerial positions both in Chicago and New York. For the past fifteen years he was in charge of Apparatus Sales.

Mr. Reade was active in many technical and fraternal organizations including the International Acetylene Association and the AMERICAN WELDING SOCIETY, and was a life member of Highland Lodge No. 80 F. & A. M. He leaves a very wide circle of friends and business associates throughout the United States and Canada. During the war he served with distinction as Chairman of the Manufacturers Committee of Welding and Cutting Division of the War Production Board.

Mr. Reade is survived by his wife, Myra Wines Reade, and daughter, Jane. His only son, Lieutenant William A. Reade, was killed in action while serving with the Field Artillery in France during World War II.

WELDED STRUCTURE

Arc welding continues to play a major role in the architectural changes in the skyline of Houston, Texas, and the latest completed welded structure is an eight story addition to the Commerce Building Garage. Some seven hundred twenty tons of structural steel has been used to frame eight additional floors to an existing four-story parking garage, and all field connections have been welded under the AMERICAN WELDING SOCIETY Code for Arc and Gas Welding in Building Construction.



The design has made use of flexible connections throughout to conform to the design employed when the original building was erected some eight years ago using riveted connections. The addition just completed was fabricated with riveted connections, and welding was employed throughout in the field.

This structure was designed by A. C. Finn, architect, and Robert J. Cummins, engineer, and the general contractor is W. B. Bellows Construction Corp. Inspection of shop fabrication and supervision of field work was handled by Southwestern Laboratories.

AIRCO PACIFIC APPOINTS FOUR NEW VICE-PRESIDENTS

Appointment of four vice-presidents has been announced by Harold P. Etter, president of Air Reduction Pacific Co., the new subsidiary of Air Reduction Co., Inc., recently organized to take over the West Coast business of Air Reduction Sales Co.

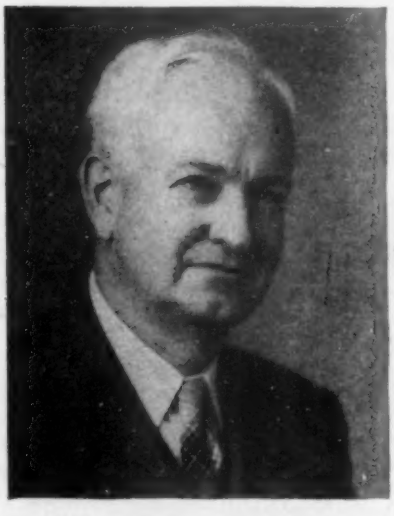
Following are the names and respective districts of the new vice-presidents; L. A. Hamilton, Seattle; E. W. MacCorkle, Jr., Portland; H. W. Saunders, San Francisco; H. A. Hoth, Los Angeles.

The company's Seattle district with offices at 3623 East Marginal Way, Seattle, Wash., includes nearly all of the state of Washington, the northern part of Idaho and part of Montana. Mr. Hamilton, vice-president in charge, graduated from Rice Institute in 1929 and began work with Air Reduction in 1930. He served with the armed forces during the war, and was discharged in 1945 with the rank of captain.

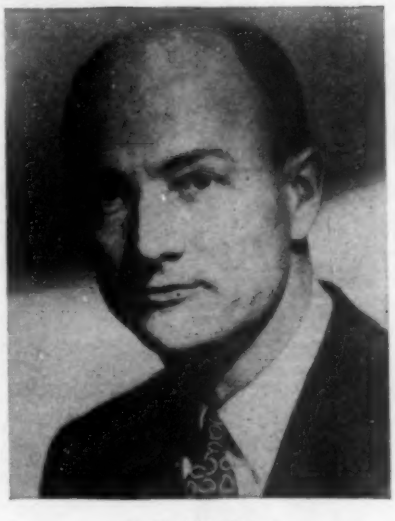
The Portland District with offices at 430 N. W. 10th Ave., Portland, Ore., includes the state of Oregon, the southern half of Idaho and a part of the state of Washington, in the vicinity of Walla Walla. Mr. MacCorkle, vice-president in charge, graduated from Washington and Lee and Cornell universities, respectively. During World War II he served as ship maintenance officer on the staff of the commandant of Naval Operating Base, Leyte, P. I. He had the rank of commander, and was in charge of seven floating drydocks and a group of repair ships and tenders, in addition to shore facilities.

The San Francisco district with offices at 1485 Park Ave., Emeryville, Calif., includes northern California north of the Kern County line, as well as most of northern Nevada and northern Utah. Mr. Saunders, vice-president in charge has been with the company about 30 years. He is an honorary life member of the AMERICAN WELDING SOCIETY, secretary of the Emeryville Industries Association, and secretary of the California Inter-Collegiate Football Officials Association.

The Los Angeles district with offices at 2423 E. 58th St., Los Angeles, Calif., includes southern California, most of the state of Arizona, and parts of southern Nevada and southern Utah. Mr. Hoth, vice-president in charge, has been with the company about twelve years. He attended Syracuse University after serving in the Royal Air Force in World War I as a flying officer.



H. W. Saunders



L. A. Hamilton

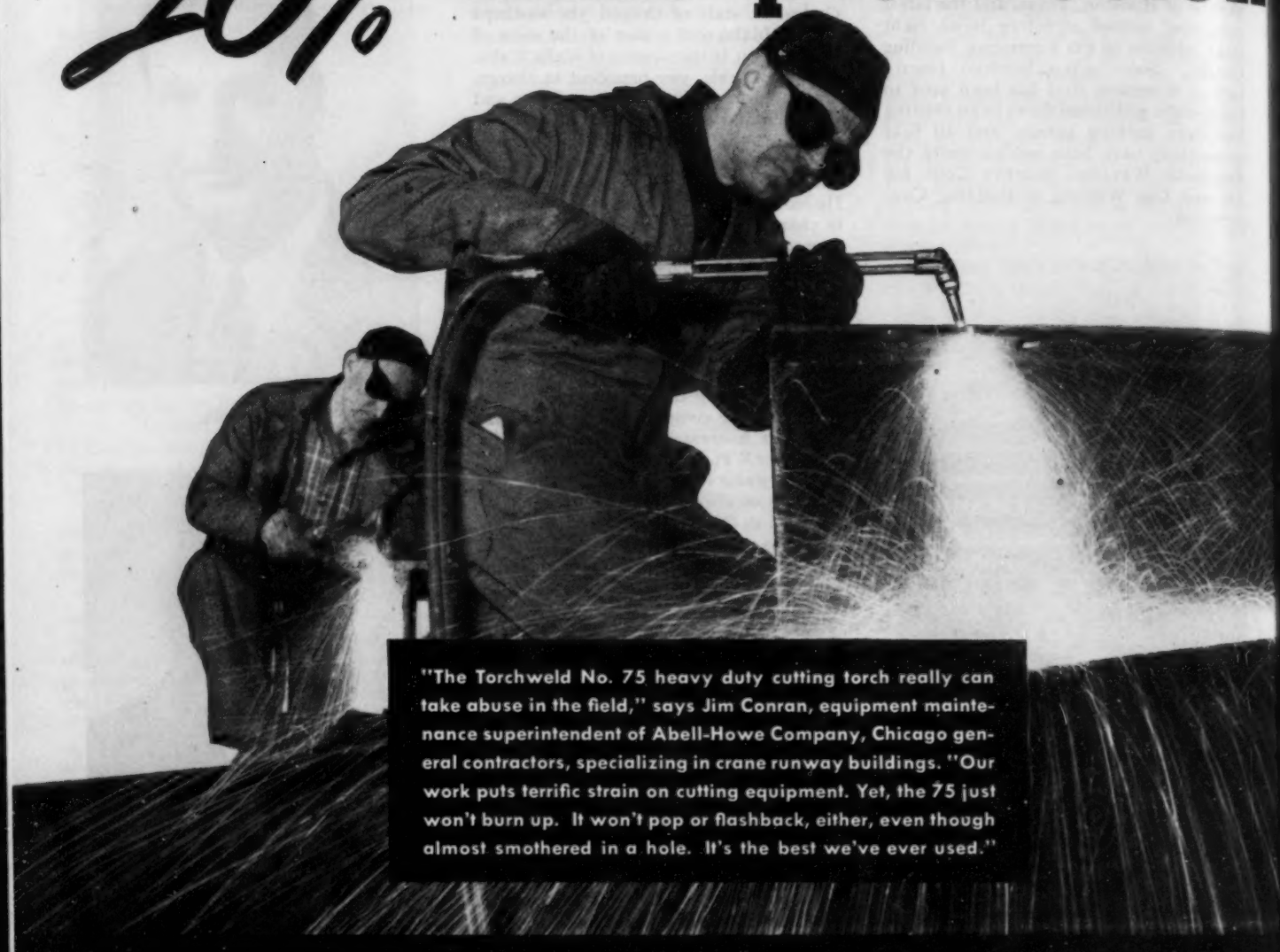
H. A. Hoth

H. P. Etter

Air Reduction Pacific Co. produces and sells oxygen, acetylene and the necessary apparatus for the oxyacetylene cutting and welding processes; it also distributes arc-welding machines, and equipment and supplies for electric welding. The company supplies shipyards, railroads, steel mills, foundries, aircraft plants and many other industrial plants.

Prior to formation of the new company, the West Coast business of Air Reduction Sales Co. was conducted through local district offices, and the company's headquarters were in New York. The increasingly important west coast markets, however, emphasized the need for greater local authority in order to better serve the needs of customers, and the formation of Air Reduction Pacific Co. with headquarters in Mills Tower, San Francisco, was the result.

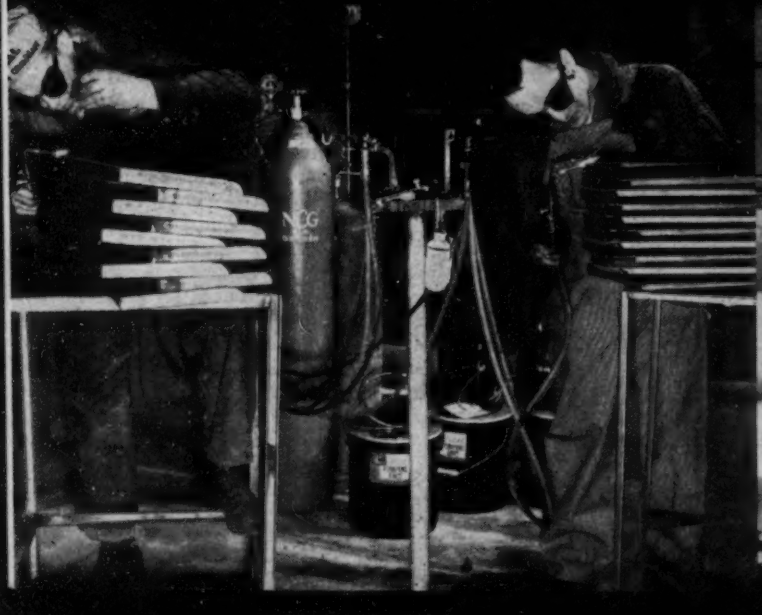
20% More production

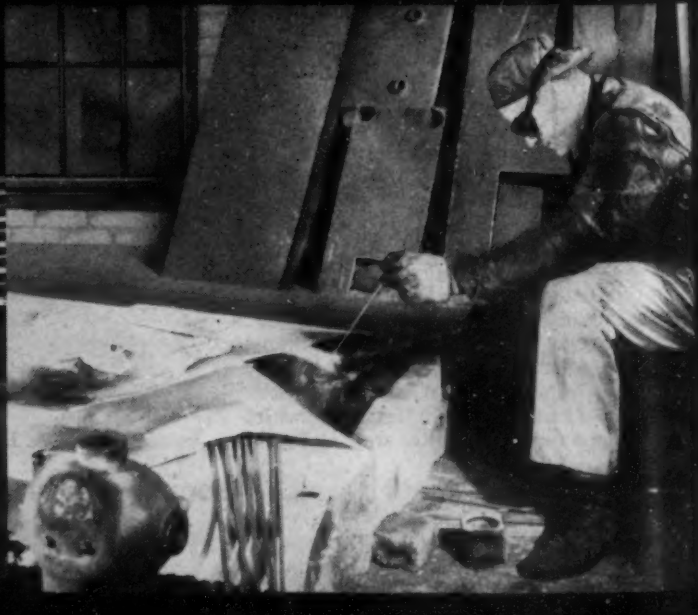


"The Torchweld No. 75 heavy duty cutting torch really can take abuse in the field," says Jim Conran, equipment maintenance superintendent of Abell-Howe Company, Chicago general contractors, specializing in crane runway buildings. "Our work puts terrific strain on cutting equipment. Yet, the 75 just won't burn up. It won't pop or flashback, either, even though almost smothered in a hole. It's the best we've ever used."

"We get an average of 20% more production using the Torchweld No. 44 Bantam welding torch than with any other torch we have ever used for flame welding light metals," says Emil Muench, foreman of the sheet metal department of Gray-Mills Corp., Evanston, Ill., manufacturers of degreasing machines and coolant equipment. "We have used NCG products exclusively for the past four years, and the Torchweld Bantam is just another reason why. The light, easy-to-use Bantam lets a man work all day without excessive fatigue."

"This company has been a user of NCG products for 10 yea and the new Torchweld line measures up to the high stand of quality that has always characterized NCG supplies a service," says Anton Boccaccio, owner of Chicago Weldi and Boiler Company, general welding contractors. "T Torchweld 54 welding torch is typical. We subjected it to brutal test in a job requiring heavy pre-heat, and it perform perfectly. No popping and no backfire!"





PAGE *Welding* ELECTRODES

STEP 1 toward better production welding

"Getting in touch with Page" doesn't always mean ordering a shipment of welding electrodes or rods. Sometimes it means getting some up-to-the-minute information on the right size or analysis of rod—the most efficient welding technique—how some other welder has licked the same kind of problem that comes up in your plant.

Your PAGE distributor is a responsible source for all types of electrodes and rods—specializing in PAGE-Allegheny stainless steel. And if he doesn't know the answer to your welding question, he can get the answer from a PAGE Field Service Man. So we say . . .

Get in touch with your PAGE Distributor

ACCO

Monessen, Pa., Atlanta, Chicago, Denver, Detroit, Los Angeles, New York, Philadelphia, Pittsburgh, Portland, San Francisco, Bridgeport, Conn.

TRADE MARK

PAGE STEEL AND WIRE DIVISION
AMERICAN CHAIN & CABLE

RUNNING A MACHINE SHOP

This book, written by Fred H. Colvin, Editor Emeritus of *American Machinist*, and Frank A. Stanley, Consulting Engineer and Editor of *Western Machinery and Steel World*, is a valuable manual that helps you solve the problems that arise in the operation of your shop whether you are a machine shop owner or manager. It provides a wealth of specific management pointers that enable you to achieve more efficient and profitable operation. It is a complete and practical guide to effective practices for both large and small shops—covering everything from methods of determining what kind of jobs the shop can best handle, to a complete tool room system—from an outline and analysis of shop operations and examples of wage payment plans, to pointers on saving costs in selecting and using machines.

The book supplies tips for increasing profits in every shop operation. It tells you how to set up and equip the shop, how to plan work, how to inspect and control it, where economies may be made, how production may be improved, how to keep records, how to manage the men—in short, how to adapt all of the best methods of shop operation to your own setup, no matter what its size. For your practical use, workable methods and suggestions have been taken from the practice of leading shops of all types and sizes.

This newly revised second edition features a special 40-page supplement covering improved techniques developed recently and including important new standards and methods. Fact-filled pages of practical information gleaned from wartime experience bring you particularly helpful pointers on job evaluating, rating and rotation to prevent monotony and to give a more flexible working force; windowless shops; use of standard machine tools; shop and toolroom layout; uses of models as well as drawings; rate setting in a small shop and scores of others.

In addition, this valuable supplement includes practical, useful data on the use of color in the shop, selection of small motors, machining of Dow metal or magnesium, and planer and shaper practice, as well as recent data on milling and honing.

Every machine shop owner and operator will find this revised manual packed more than ever with money-saving, efficiency-building tips that insure smooth, first-rate operation at minimum cost.

Second Edition. Price, $4.25.

NEW ELECTRODE WALL CHART

A 25 by 35-in. electrode wall chart, beautifully printed in full color has just been published by The Hobart Brothers Co., Troy, Ohio.

This handy wall chart shows procedures for every type of arc-welding electrode; actual results of too long or too short an arc, too much or too little welding heat, too fast or too slow a welding speed, and then shows a perfect bead as well as a cross section of all welds; and complete illustrated welding symbols for both fusion and resistance welding.

A copy of this chart will be mailed free of charge to anyone on request to The Hobart Brothers Co., Troy, Ohio.

EUREKA ALLOY WELDING ELECTRODES

A new 12-page catalog lists the following Eureka Electrodes, their properties, recommended uses and procedures for application:

Pure Nickel Electrodes.
Copper-Nickel Electrodes
"Drawalloy" Electrodes
Heat Resisting Alloy Electrodes
Bronze Electrodes
Copper Electrodes

For information, write **Welding** Equipment & Supply Co., 223 Leib St., Detroit 7, Mich.

THIRD SOUTHERN MACHINERY AND METALS EXPOSITION TO BE HELD IN ATLANTA, GEORGIA, APRIL 5-8, 1948

The Third Southern Machinery and Metals Exposition will be held in the Atlanta Municipal Auditorium, April 5, 6, 7 and 8, 1948. Exhibitors for the 1948 Exposition will come from coast to coast, and from the Great Lakes to the Gulf. Many Southern companies, as well as national organizations, will be included.

Manufacturers of machinery and tools; metal products; materials handling equipment; oils and lubricants; welding and safety equipment; ferrous and nonferrous castings and forgings; electronic apparatus; chemicals and detergents will exhibit their products. Lathes, saws, presses, drills and a variety of industrial equipment used in Southern plants will also be shown. The steel industry will be represented with outstanding exhibits by some of the leading companies.

National

Carbide

IN THE RED DRUM

EFFICIENT

ECONOMICAL

DEPENDABLE

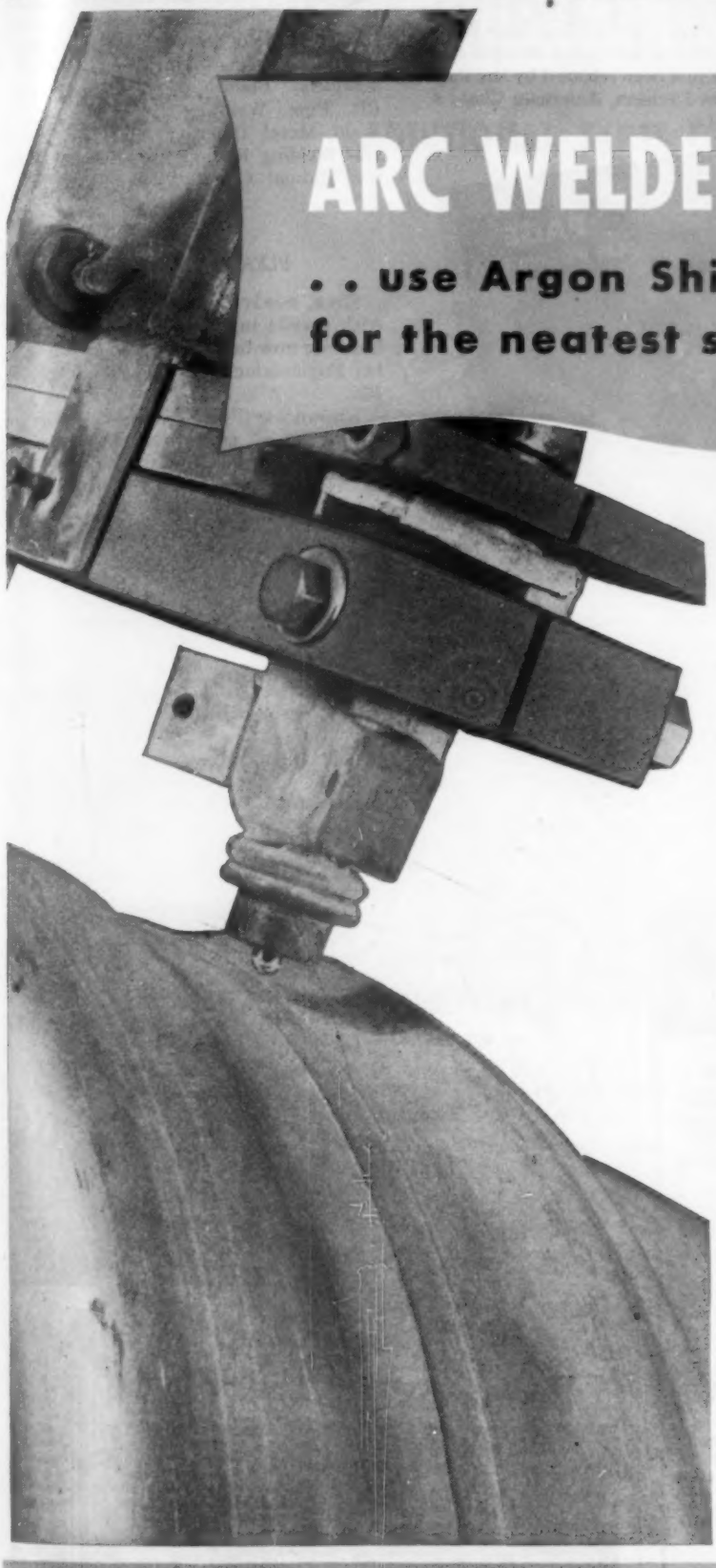
FOR WELDING and CUTTING

Use National Carbide in the Red Drum

Write us for information as to nearest available stock.

60 E. 42nd St. NATIONAL CARBIDE CORPORATION New York 17, N. Y.

WELD ALUMINUM BY ALL COMMERCIAL METHODS



ARC WELDED ALUMINUM

. . use Argon Shielded Tungsten Arc for the neatest seams you ever saw

No flux . . . no post-weld cleaning . . . high strength . . . smooth, flat appearance . . . no slag or flux inclusions . . . these are advantages of using this method for welding Alcoa Aluminum. A good welder can learn to use the tungsten arc with argon shielding easily.

When you figure cost per foot *as finished*, argon shielded tungsten arc welding compares favorably with the other methods of welding. You save the labor cost of dissolving or scrubbing flux from the welded seams. And there's no possibility of corrosion from welding flux when you use this method.

BOOKLETS . . . MOVIES TO SHOW YOU HOW!

There's complete information on argon shielded tungsten arc welding in the booklet, "Welding and Brazing Alcoa Aluminum". Write for your copy today.

You can also have 16-mm sound motion pictures on Gas, Arc, and Resistance Welding Aluminum to show your shop people and designers on your own projector. Write to ALUMINUM COMPANY OF AMERICA, 1933 Gulf Building, Pittsburgh 19, Pennsylvania. Sales offices in 54 leading cities.

ALCOA FIRST IN ALUMINUM

REG. U. S. PAT. OFF.

ALCOA ALUMINUM

IN EVERY COMMERCIAL FORM

ANNUAL MEETING, SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS

The Annual Meeting of the Society For Experimental Stress Analysis will be held at The Roosevelt Hotel, Pittsburgh, Pa., on May 27, 28, 29, 1948. Inquiries should be addressed to the Society for Experimental Stress Analysis, P. O. Box 168, Cambridge 39, Mass.

WELDING FITTINGS

Taylor Forge Bulletin 476, *Stainless Steel Dimensional Data*, describes welding fittings from $^3/_4$ in. to 12 in., and lightweight American Standard flanges from $^3/_4$ in. to 30 in., all available in stainless types 304, 316 and 347, monel, inconel, nickel, copper and other usual industrial metals. Taylor Forge & Pipe Works, P. O. Box 485, Chicago 90, Ill.

SALVAGE OF CASTINGS

Practical procedures for salvaging cast iron, bronze, aluminum and malleable iron castings—with emphasis on machine shops and foundries of heavy machine builders, where the problem becomes acute—are set forth in a compact illustrated 2-page bulletin issued recently by Eutectic Welding Alloys Corp., 40 Worth St., New York 13, N. Y.

NEW PAGE GAS WELDING WIRE CATALOG

The new Page Gas Welding Rods Catalog, believed to be the first of its kind ever printed, has just been released by the Page Steel & Wire Division, American Chain & Cable Co., Inc.

This attractive, 3-color, 24-page brochure is devoted exclusively to Gas Welding Wire and its use. Easy-to-find index plus orderly, clean-cut layout, makes this catalog very easy to use. It covers the complete Page line; gives the application—procedure—proper torch adjustment—physical properties, etc., of each gas welding rod. And on the back cover, there's a convenient reference chart, "Page Welding Electrodes and Gas Welding Rods." Numerous application photographs are shown throughout the booklet. Information in this catalog exceedingly helpful to welders includes: (1) Oxyacetylene Flames; (2) Torch Tips; (3) Pipe Welding; (4) Weights of Weld Metal Deposit; (5) Weights of Gas-Welding Rods; (6) Estimate Cost for Manual Oxyacetylene Welding.

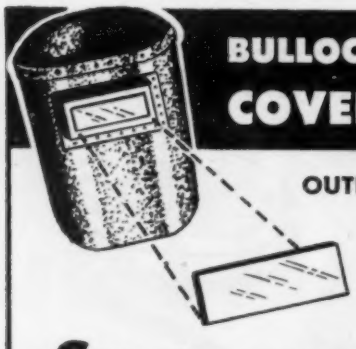
PLEASURE CRUISERS

Sleek, newly designed pleasure cruisers with speeds ranging up to 26 miles per hour are now being produced by the Florida Engineering & Dry Dock Co. Miami, Fla.

Known as "Fulton Cruisers," they are available in two models—the Sedan Cruiser and the Sport Cruiser. Each model has sleeping accommodations for four people. They are 26 ft. 11 in. in length, have a 9 ft. 2 in. beam, 1 ft. 10 in. draft, and are powered by twin Chrysler engines developing 172 hp. Charles D. Roach, Inc., designed them.

J. W. Fulton, general manager of the Florida concern, who has gained a national reputation as a welding engineer, reports the new craft are designed to "spread the waves," to minimize the amount of spray in choppy water.

Hulls of Fulton Cruisers are of all-welded construction and made of wrought iron plates. With the welded wrought iron hull, Mr. Fulton explains, the boats



BULLOCK Coated ★ COVER GLASSES

OUTLAST OTHERS 10 to 1
SPLATTERPROOF
WATERPROOF
BETTER VISION

SEND FOR A TEST BOX OF 10 FOR $1

Pin a dollar to the coupon and mail it right now. It will save you lots of dollars later. You'll find that Bullock Coated Cover Glasses last 10 to 20 times as long as ordinary cover glasses. Navy Yards and shipbuilders bought Bullock glasses by the millions during the war because they eliminated frequent changes and they produced better welding by improving vision and ending eyestrain.

Bullock Cover Glasses are coated front and back with an amazing waterproof compound that sheds metal splatter, prevents heat-breakage, improves visibility. You ought to be using them...they cost so little! They save so much! Give them a trial.

DEALERS: You ought to be selling them. It's profitable! Write for details.

LIST PRICES
15c EACH
100 for $12.00
500 for $45.00
1000 for $67.50

Further discounts for larger quantities

Also 50 mm. Goggle Glasses

L. H. BULLOCK CO. 2 EIGHTH ST. RICHMOND CALIF.

Mail this with $1

L. H. BULLOCK CO., 2 Eighth St.
Richmond, Calif.
Send me 10 Bullock Cover Glasses. I'll test them.

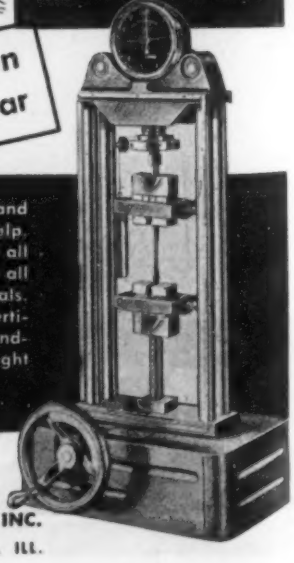
.....

.....

DILLON Tensile TESTER

Provides every concern, smallest to largest,. with its own outfit for precision testing to highest standards — lowest cost.

Tensile • Compression
Transverse • Shear



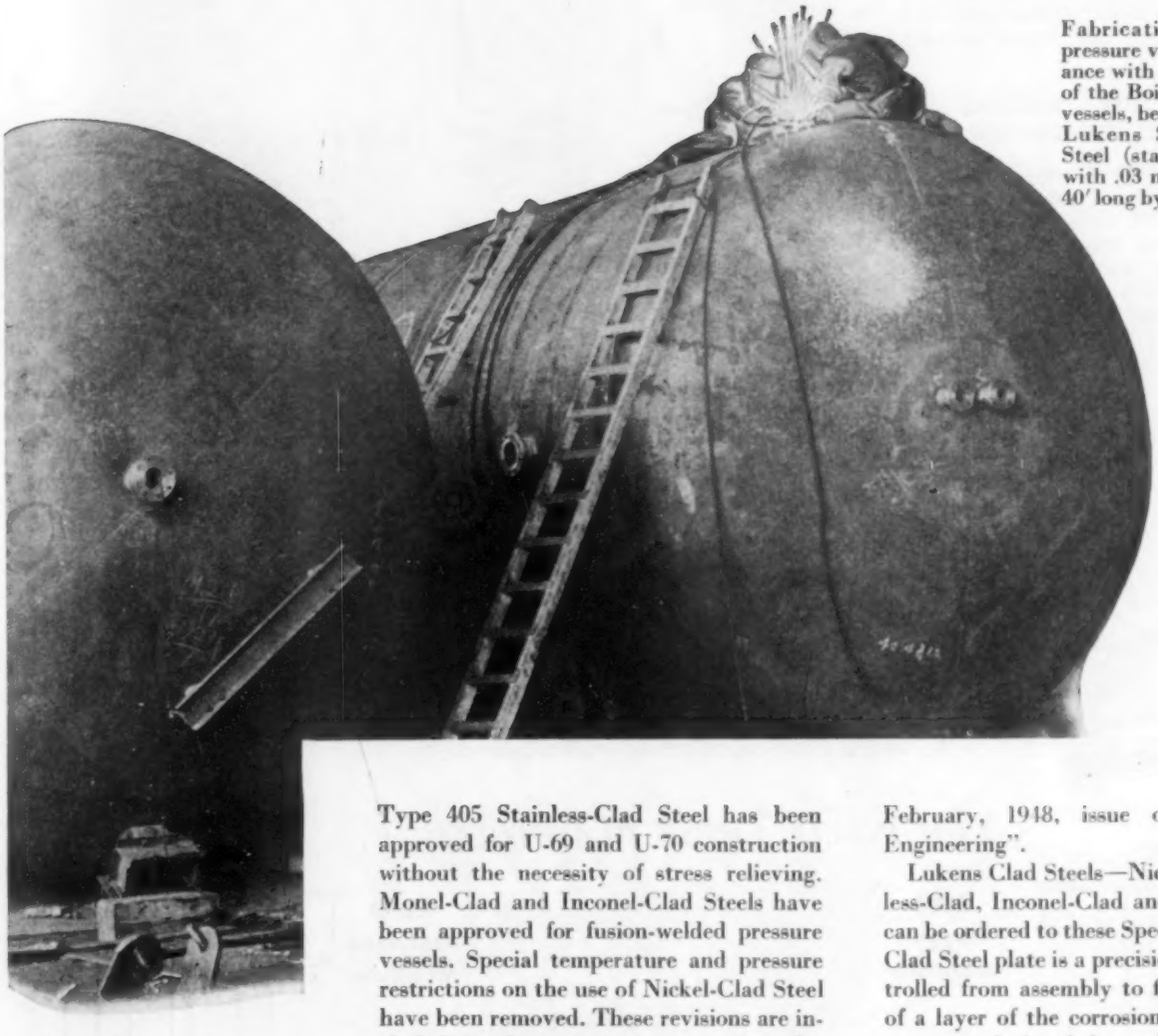
Compact — ruggedly built — easy and fast operation even by untrained help. Capacities from 250 to 10,000 lbs., all in the same tester. Tests accurately all shapes, round, flat, special, all materials. Calibrated with Morehouse Ring, certified by U. S. Bureau of Standards. Hand-operated or motorized. Overall height 37". Net weight 132 lbs. *Prompt delivery.*

Ask for Bulletin Valuable Engineering Testing Charts, free. Wire or write

W. C. DILLON & CO., INC.
4510 WEST HARRISON ST., CHICAGO 44, ILL.

ASME Boiler Code Committee Approves

ADDITIONAL TYPES OF CLAD STEEL PLATE COMPLYING WITH ASME CLAD STEEL SPECIFICATIONS FOR FUSION-WELDED PRESSURE VESSELS



Fabricating Clad Steel pressure vessels in accordance with paragraph U-69 of the Boiler Code. These vessels, being built of 15% Lukens Stainless-Clad Steel (stainless type 316 with .03 max. carbon) are 40′ long by 13′ in diameter.

Type 405 Stainless-Clad Steel has been approved for U-69 and U-70 construction without the necessity of stress relieving. Monel-Clad and Inconel-Clad Steels have been approved for fusion-welded pressure vessels. Special temperature and pressure restrictions on the use of Nickel-Clad Steel have been removed. These revisions are included in the new interpretation under Case 896 of the ASME Boiler Code.

Materials covered by this approval are described in ASME (also ASTM) Specifications SA-263 on chromium steel clad plates, SA-264 on chromium-nickel steel clad plates and SA-265 on nickel and nickel-base alloy steel clad plates. Complete details of the Case appear in the February, 1948, issue of "Mechanical Engineering".

Lukens Clad Steels—Nickel-Clad, Stainless-Clad, Inconel-Clad and Monel-Clad—can be ordered to these Specifications. Each Clad Steel plate is a precision product, controlled from assembly to finish, consisting of a layer of the corrosion-resistant metal permanently bonded to a backing plate of ASME specification steel.

Lukens Clad Steels represent the most complete range available to industry. For additional information write for Bulletins 338 and 255, Lukens Steel Company, 407 Lukens Building, Coatesville, Pennsylvania.

CLAD METAL STEEL

LUKENS

Nickel-Clad Stainless-Clad
Inconel-Clad Monel-Clad
STEELS

SOLID METAL ADVANTAGES WITH CLAD STEEL ECONOMY

require little maintenance. Caulking is eliminated and the possibilities of leaks are remote.

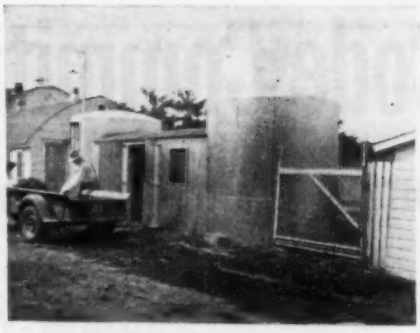
"In a pleasure craft—or any other type of vessel for that matter—the idea of low maintenance has a significant appeal," Mr. Fulton says. "Besides the expense of dry-docking and labor required, the craft is useless to its owner when laid up for maintenance or repair.

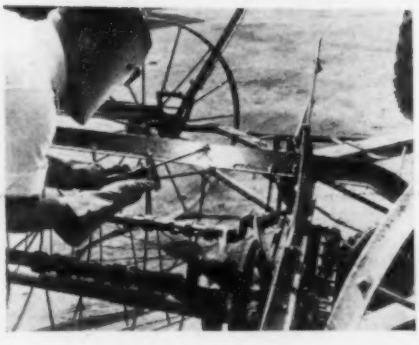
"It was our purpose to design a cruiser that would stand up many years in salt water service. We realized the corrosive effects that salt water has on metal hulls but the record of boats with wrought iron hulls—some of them 100 years old—led us to believe that this metal was most suitable for our new cruisers," Mr. Fulton states.

MOTION PICTURE—"WELDING COMES TO THE FARM"

To illustrate the importance of arc welding to the average farmer, and to show how welding is used on the farm in hundreds of different interesting ways, The Lincoln Electric Co., Cleveland, Ohio, has produced a new motion picture, "Welding Comes to the Farm."

The picture is a black and white 16 mm. sound film which runs 24 min. Filmed mainly on farms in the midwest, the movie shows how farmers have saved themselves valuable time and money by having a welder on their places for repairing broken and worn parts and for building handy equipment and machinery. In addition to showing the many uses for arc welding, the film also depicts a farm welding "demonstration" that explains the welding process and just how the equipment works.

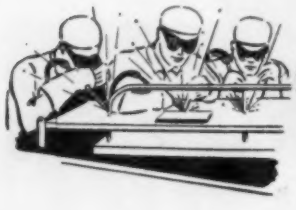




Actual on-the-farm scenes illustrate such homemade equipment as a granary made from an old beer tank, a hay loader and a smoke-stack made from old hot water tanks. Repairs are shown being made on such equipment as a worn plow

---

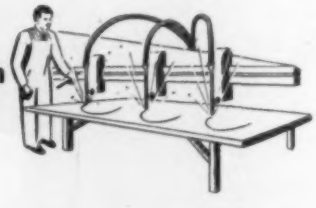
FOR THESE JOBS . . .



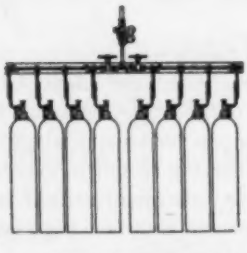
Production Welding

. . . and operations such as welding and cutting heavy sections with hand torches, flame hardening and softening, flame cleaning . . . also any installation where a battery of cylinders is required.

Production Cutting

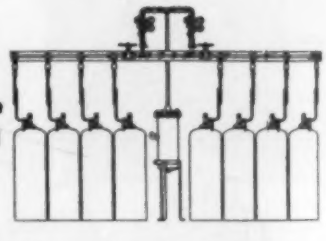


YOU NEED THESE MANIFOLDS . . .



REGO Oxygen Manifold

REGO Acetylene Manifold



BECAUSE OF THESE ADVANTAGES...

- ***Added Convenience***...Individual shut-off valves at each cylinder station permit the removal of any cylinder without shutting down one side of the manifold. Master shut-off valves control flow of each bank of cylinders.
- ***Unit Construction***...Header assembly, mounted to steel I-beam, is virtually one piece. Extra-heavy pipe is run through header fittings, cylinder station shut-off valves and master shut-off valves with all permanent connections silver-brazed.
- ***Precision Regulation***...Uniform delivery pressure is assured by large capacity two-stage Regolators.
- ***Exacting Tests***. . . Every RegO Manifold is subjected to a sustained air pressure test before shipment.

REGO® Manifolds for Oxygen . . . Acetylene . . . Hydrogen . . . Nitrogen and other high pressure gases

There Is A RegO Manifold to Fit Your Most Exacting Requirements

The BASTIAN-BLESSING Company

*Reg. U. S. Pat. Off.

4201 W. Peterson Avenue Chicago 30, Illinois

Pioneer and Leader in the Design and Manufacture of Precision Equipment For Using and Controlling High Pressure Gases

CHAMPION WELDER

MACK NEWTON of American Frog and Switch Co., *Hamilton, Ohio*

Says: **"I have used CHAMPION WELDING ELECTRODES for several years to fabricate crossing plates and headlocks. They do an excellent job in all positions and no matter what you are up against, a CHAMPION will give you a better finished weld faster than any other electrode."**

Mack Newton is one of hundreds of veteran welders who prefer CHAMPION WELDING ELECTRODES. He realizes that to achieve champion production you need an electrode which is superior in penetration, ease of starting and all 'round handling — in short, a CHAMPION ELECTRODE.

For
CONSISTENTLY OUTSTANDING RESULTS
Use
CHAMPION Welding Electrodes!

A "Team" of CHAMPIONS covers every welding requirement. Send for bulletin describing each electrode and its application.

CHAMPION Electrodes are Weld Rated Electrodes

THE CHAMPION RIVET COMPANY

CLEVELAND, OHIO **EAST CHICAGO, IND.**

axle and a disk harrow that broke down in the field. Loosening a rusted nut with the heat of an arc torch is another neat touch shown being done with the new welder built just for farm use.

As can be seen in this motion picture, the rapid spread from the city to the country of the modern industrial process of arc welding is opening remarkable new possibilities for the use of metals on the farm. The arc welder and the electrode are rapidly replacing the hammer and the nail.

Many farmers will be completely surprised at how simple arc welding really is as it is used on the farm. Welding machines, as they are sold by leading manufacturers today, come completely equipped and ready to use. An hour or two spent reading the instruction manual and in practicing with the machine is generally all that is needed to perform simple welding operations.

"Welding Comes to the Farm" is now available on loan for showing to all interested groups, 4-H Clubs, FFA Chapters, Granges, schools, etc. There is no charge except for transportation. Prints of the film may be had by writing to The Lincoln Electric Co., 12818 Coit Road, Cleveland, Ohio.

TEN-YEAR-OLD ALL-STAINLESS STEEL SANTA FE COACH PASSES SEVERE TESTS

Ten years' continuous service over 2,500,000 miles has had no appreciable effect on the structural strength of the all-stainless steel Budd-built railway car which was subjected to tests in the Company's laboratory here, according to General Gladeon M. Barnes, Vice-President in Charge of Engineering.

The tests, a joint operation by engineers of The Budd Co. and the Atchison, Topeka and Santa Fe Railway Co., were conducted under the supervision of Michael Watter, Chief of Budd's Research and Development Division. They were observed by an official representative of the American Association of Railroads. Testing operations took place in Budd's testing plant, part of the Company's research facilities which were offered recently for use by any railroad, car builder or other organization. Railway cars may be subjected to compression loads up to 2,000,000 lb. in this plant, which is said to be the only one of its kind in the world.

"This car," said Dr. Watter, "one of the one hundred chair cars delivered to the Santa Fe during 1937, was built when the strength requirements for railway passenger cars were lower than present-day standards. Then, as now, Budd built extra strength into all its cars, and after a careful review of the original engineering analysis, we were able to assure the Santa Fe that because stainless steel structure is truly corrosion-resistant, the originally built-in margins of extra strength were adequate to meet present A.A.R. requirements of 800,000 lb. compression loads. Minor reinforcements were added to various low-alloy steel elements of the car including the end under-frame unit, coupler, coupler carrier, center plate and collision posts. No modifications were made to the all-stainless steel car structure."

The car, taken from a regular run of the Santa Fe, was subjected to an 800,000-lb. compression load. Not only did it withstand this load without permanent deformation, but also without even cracking a single window pane as all glass had been left in place for the test.

"Our prediction that the car would pass the tests was based on the original engineering analysis plus our conviction that ten years of service had no deteriorative effect on the stainless steel of which the car is made, detail design, or the Budd Shotweld process of fabrication. The test proves that the bases of our predictions are sound," said Dr. Watter.

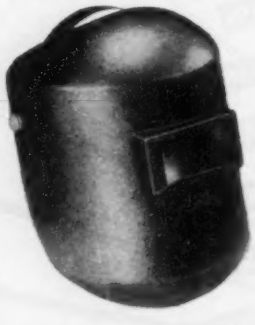
Shortly after the test the car was returned to service by the Santa Fe.

NEW SAFETY DIRECTORY

The new Best's Safety Directory for 1948—covering the entire field of Safety, Fire Protection and Control, Hygiene, First-Aid and Sanitation—is now available to industry, as recently announced by the Alfred M. Best Company's Safety Engineering Division.

The Directory is unique in that it cobines all the best practical features of a Safety Manual, Directory, Index, Encyclopedia and Catalog into one comprehensive, profusely illustrated, 494-page volume. It is the "*What*, *How* and *Where* Book of Safety—showing *what* safety products or devices to use for specific hazards; *how* to use them; *where* to get them. Best's was the first Safety Directory published and is still the only one in the field. Last year's first annual edition

SERVICE•BUILT FOR BETTER SERVICE•BUILT FOR BETTER



One Piece Molded Safety!

Here's practical, fine quality protection at a price you can afford.

Molded from one piece of sturdy fibre. No rivets to loosen, tear or burn out. Shock proof and light proof. Deep molded for positive protection. Well ventilated, comfortable and easily sterilized. Convenient, quick adjusting headgear.

Model 1250 shown here, is available with quick-change, metal coverplate, lense holder.

Write for our Welding & Safety Equipment Catalogs.

DOCKSON CORP. 3839 WABASH • DETROIT 8, MICH

•BUILT FOR BETTER SERVICE• Dockson

BUILT FOR BETTER SERVICE•BUILT FOR BETTER SERVICE•BUILT FOR BETTER SERVICE • BUILT FOR BETTER SERVICE • BUILT FOR BETTER SERVICE •

Buy "Proven Fluxes" with Years of Guaranteed Satisfaction behind them

The Trade-Name is "ANTI-BORAX"

Ask for Them ***Unequalled for Quality***

A Flux for every metal: Cast Iron Welding Flux No. 1; Brazing Flux No. 2; Braz-Cast Flux No. 4 for bronze-welding cast iron; "ABC" Aluminum Flux No. 8 for sheet Aluminum and all alloys of Aluminum; Stainless Steel Flux No. 9; Silver Solder Brazing Flux No. 10; No. 16 Silver Solder Paste Flux.

ANTI-BORAX COMPOUND COMPANY

Fort Wayne, Indiana

TIP CLEANING DRILLS

Mounted in Knurled

BRASS *Handles*

•

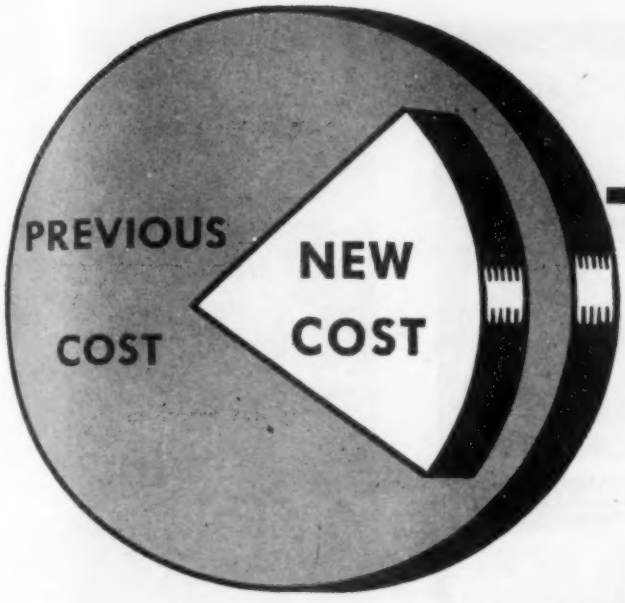
LARGE STOCK
PROMPT DELIVERY

•

DISTRIBUTORS WANTED

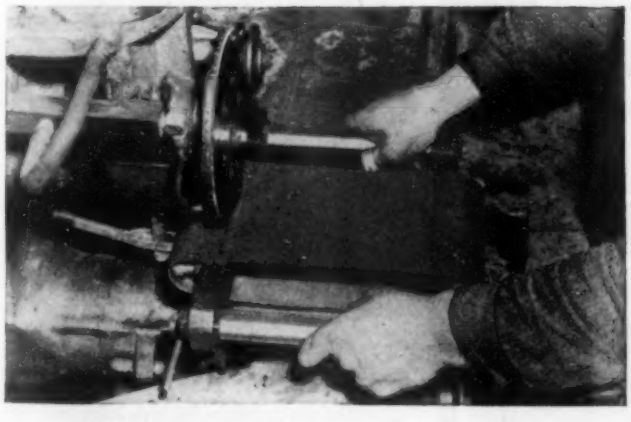
NEW MEXICO STEEL CO.

Box 691, Albuquerque, N. M.



--RESISTANCE WELDING DID IT!

Impossible?



At Heywood-Wakefield, for instance, redesigning of the coach seat pedestal for assembly by resistance welding had the following results:

1. **The Progressive Seam Welder paid for itself in the first few weeks of operation.**
2. **Since then it has been saving enough to pay the wages of 10 other H-W workers on other jobs.**
3. **A higher quality seat pedestal was produced.**

You'll find the story of how this was done along with "How 33 operations were cut to 5"; "Simple machine makes petcock wrenches faster"; "How to resistance-weld without heavy duty power lines"; and "How to design for projection welding", in

RESISTANCE WELDING PICTORIAL #50
Ask for it, today.

IT PAYS TO WELD

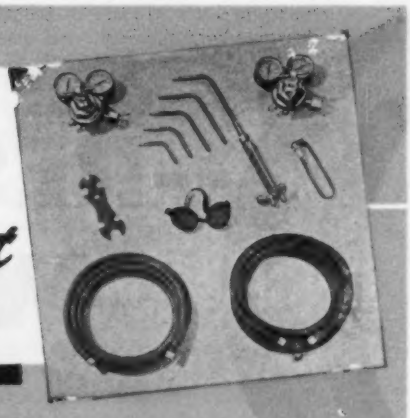
PROGRESSIVE Welder Co. 3050 E. OUTER DRIVE • DETROIT 12

CABLE ADDRESS "PROGWELD"

MEMBER RWMA

RESISTANCE WELDING EQUIPMENT

OUTFIT
for more efficient
PRODUCTION



use this

QUICK SOURCE OF SUPPLY

SOS

BURDOX WELDING • CUTTING SAFETY EQUIPMENT

REGULATORS and GAUGES
Outstanding for Accuracy

CUTTING and WELDING TORCHES
for every purpose

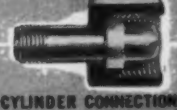
LIFT FRONT GOGGLES
Head protector mounts goggles

EXTRA FLEX WELDING CABLE
Helps the Welder do a better job

STREAMLINED LIGHT WEIGHT
HELMETS & HAND SHIELDS

PORTABLE CYLINDER TRUCKS
Nothing like them at any price

PLASTIC FACE SHIELDS
Wide vision wide protection



CYLINDER CONNECTIONS
All brass, precision made

Take advantage of big savings in time and money by standardizing on BURDOX products for all your welding and cutting needs. Designed by welding men for welding men, every BURDOX product offers you the latest improvements and superior quality at prices that mean savings to you. At all leading welding supply distributors.

THE BURDETT OXYGEN CO.
2338 LAKESIDE AVENUE • CLEVELAND, OHIO
Since 1924
IF IT'S FOR WELDING OR CUTTING, WE HAVE IT!

SEND ME A FREE COPY OF THE NEW BURDOX 64-PAGE CATALOG.

NAME.....
FIRM.....
ADDRESS.....
CITY & STATE.....

was enthusiastically welcomed by every type of industry.

One outstanding feature of this book is its indexing and subject-grouping system. These devices—plus countless illustrations—make it easy to locate safety products even when the user is not certain of the type or name of the product he needs. The logical arrangement of subjects also serves as a checklist of hazards—many of which are frequently overlooked. Typical sections are *Arm and Hand, Body and Leg, Eye and Face, Fire,* etc.

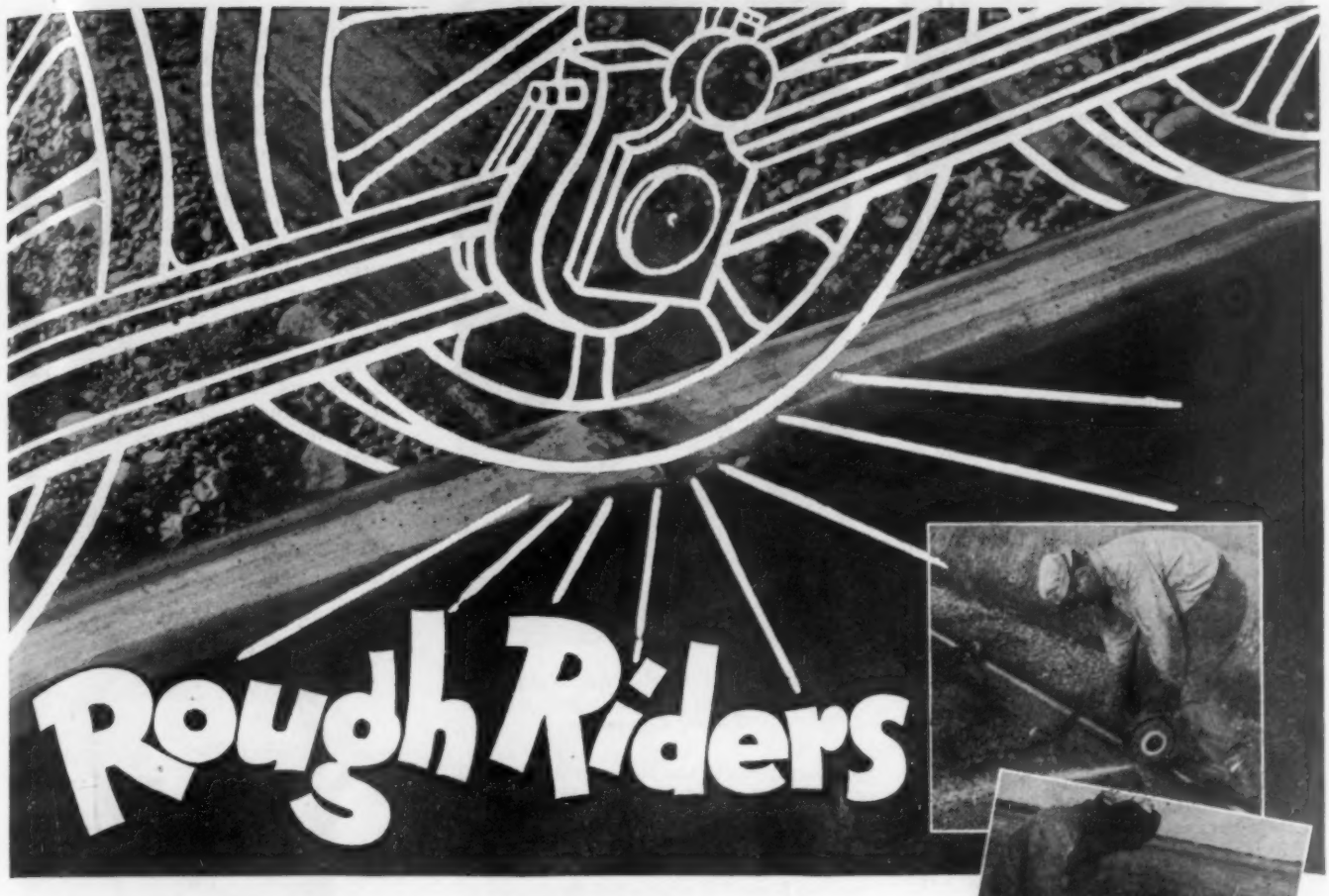
The Directory is endorsed and used by the leading compensation insurance companies and includes the standards established for safety equipment by the leading standards groups.

The book is priced at $5.00, with lower rates for quantities. Either the Directory itself or complete information may now be obtained from the home office of the Alfred M. Best Co., 75 Fulton St., New York 7, N. Y., or at any of their branch offices in Atlanta, Boston, Chicago, Cincinnati, Dallas, Chattanooga or Los Angeles.

FREIGHT CAR ASSEMBLY LINE

Freight car production has been further accelerated by the installation of an assembly line based on radically new methods of manufacture for the construction of all-welded steel cars at the Chicago plant of the American Car and Foundry Co., according to an announcement made today by R. W. Ward, vice-president in charge of production.

"Revolutionizing the production of cars, this ACF-engineered improvement takes advantage of the most advanced automatic submerged welding techniques," said Mr. Ward. "To these we have added the use of pneumatic clamps and adjustable frames to hold a complete car roof or side



cured with Amsco Railface . . .

"Rough Riders"—that's an heroic term, in history books, but not when it's applied to the rails over which the passenger and freight trains roll across the country. Such worn and battered rail ends as are shown above can only mean passenger discomfort and unnecessary wear and tear on equipment. Amsco Railface electrodes are giving phenomenal results in keeping rail joints smooth for rider satisfaction and reduced equipment maintenance costs.

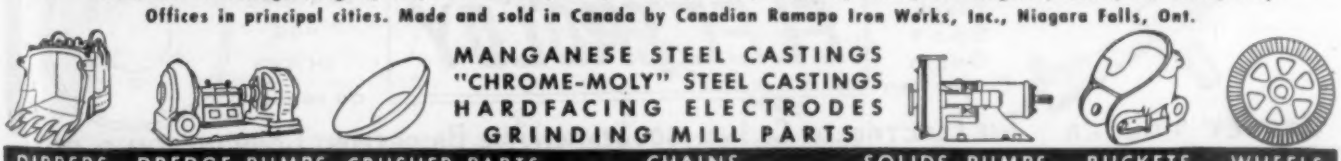
The small photographs show how the spalled or battered sections are ground, the welding operation, the joint after welding, and the completed weld after grinding ends to conform to balance of rail section. With an as-deposited Brinell of 325 to 350, work-hardening to 380 Brinell, this specialized electrode for high carbon content rail assures smooth joints that STAY SMOOTH.

This is another in the long line of Amsco Conservation Welding products that effect savings daily by reclaiming rebuilding, repairing, or hard-facing of parts subject to wear and service abuse. Complete details of all products are available in Bulletin 1047-W.

AMERICAN Brake Shoe COMPANY

AMERICAN MANGANESE STEEL DIVISION
CHICAGO HEIGHTS, ILL.

Foundries at Chicago Heights, Ill., New Castle, Del., Denver, Colo., Oakland, Calif., Los Angeles, Calif., St. Louis, Mo.
Offices in principal cities. Made and sold in Canada by Canadian Ramapo Iron Works, Inc., Niagara Falls, Ont.



MANGANESE STEEL CASTINGS
"CHROME-MOLY" STEEL CASTINGS
HARDFACING ELECTRODES
GRINDING MILL PARTS

DIPPERS DREDGE PUMPS CRUSHER PARTS CHAINS SOLIDS PUMPS BUCKETS WHEELS

to prevent slipping during welding. Where hand welding is necessary, the entire assembly can be rotated to enable welders to work down hand, which is accepted as producing the best results. The entire assembly line can be adjusted for whatever type or size car we desire to produce.

"An interesting by-product of this new technique is the assurance of greater employee safety through the use of additional protective devices and the reduction in man-power now needed to complete a freight car. Also we have a cleaner place to work as the automatic welding process leaves the atmosphere clear of sparks and smoke," Mr. Ward added.

The first cars to be produced by means of this new method are 50 high-speed express refrigerator cars for Atlantic Coast Line and 500 similar cars for Railway Express Agency. Despite the elaborateness of these cars presently under construction ACF is meeting the contemplated production of 12 cars every working day.

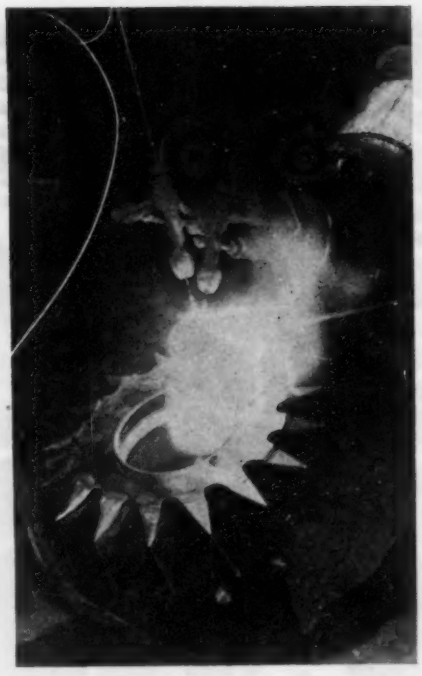
Mr. Ward stated that this manufacturing procedure will be considerably more efficient than previous freight car methods, and he expects a daily production rate of 24 box cars per day when the normal supply of steel and accessories becomes available.

Installation of these new facilities will be carried out in other ACF plants as rapidly as possible although materials required for this new equipment are still hard to procure.

USE OF ELECTRIC WELDING IN INDUSTRY

A new "More Power to America" program designed to show how increased use of electric arc welding in industry can reduce manufacturing costs and produce better products has just been released by the General Electric Co. Showings of the program, which features an all-color sound movie, "Arc Welding at Work," are being given throughout the country by local electric utilities and G-E welding distributors.

"Arc Welding at Work" features 53 outstanding electric welding applications



Scene from G.E Movie "Arc Welding at Work", Showing Atomic Hydrogen Hard-Facing Operation

photographed in the plants of metal fabricators and manufacturers. It shows the latest developments in metal-arc, atomic-hydrogen, and Inert-Arc welding, both manual and automatic. Colorful animation is used to review briefly the principles of each type of welding, and extreme close-ups show what is happening inside the arcs. Interesting sequences show many types of products on which welding has been advantageously used.

Besides the film, the new program is made up of an application manual, *Electric Arc Welding*, and a handout bulletin, *Cut Costs and Improve Quality with Electric Arc Welding*. The manual outlines in detail the advantages of welding, and contains much useful welding application data. More than 100 pages in length, it includes information on importance of proper designing for welding, power supply for welders, welding equipment, safety and many other aspects of welding. Experienced welding application engineers collaborated in its preparation.

The handout bulletin condenses the material given in the manual and film into 12 pages of information which the audience can study after viewing the program.

LESTON V-P IN CHARGE OF PRODUCTION

Appointment of Theodore I. Leston as vice-president in charge of production, Eutectic Welding Alloys Corp., was announced recently by Rene D. Wasserman, president. The company manufactures and distributes special gas and arc welding rods, fluxes and welding equipment.

A graduate of Arnstadt Polytechnic Institute in chemical engineering, Mr. Leston completed his metallurgical training at Faculte des Sciences, Paris and New York University. At the Faculte, he worked under Madame M. Curie, covering preliminary phases of atomic research.

Specializing in the industrial development of high-alloy steels, nonferrous metals, silver alloys and other metallurgical products, he was assigned to company projects in the research laboratories at the beginning of 1944. Thereafter, he guided several new arc welding electrodes and alloys through the pilot-plant stages to full production. He is a member of the American Society for Metals, American Foundrymen's Association, and the AMERICAN WELDING SOCIETY.

Theodore I. Leston

He became director of production in the late summer of 1947, and now assumes full charge of manufacturing approximately 100 types of gas and arc welding rods at 110 Duane St., New York, where the company's newly-equipped 7-story plant is located.

RESISTANCE WELDER MANUFACTURERS' ASSOCIATION ELECTS NEW OFFICERS

T. S. Long, Vice-President and General Manager of The Taylor-Winfield Corp., Warren, Ohio, was elected President of the

For Emergency Repairs

. . . weld cast iron with Ampco-Trode 10 —save time and money . . .

Typical of the way Ampco-Trode 10 saves money for its users is this tricky repair job. This cast-iron road-grader drive housing was badly damaged when a drive shaft broke. Replacements were not available. Ampco-Trode 10 took over. Only a slight preheat was necessary so that the welder had no trouble in handling the casting. All joints were V'd out and the welding done in two passes — once with an 1/8" rod and again with 3/16" rod.

One of the breaks passed through a machined flange. But the fact that Ampco-Trode 10 provided a machineable deposit as well as good strength and ductility solved this problem.

You, too, can save time and money with Ampco-Trode 10. This all-purpose aluminum bronze electrode gives you these important welding advantages:

- **Welds dissimilar metals**—steel to clean cast iron; steel or cast iron to bronze, brass, and copper; and all these to nickel alloys.
- **Ideal for bearing applications and overlays** — where hardness and resistance to wear are essential factors.
- **Resists corrosion** — this quality is extremely useful when fabricating process-industry equipment.

Get a supply of these easy-to-use, money-saving aluminum bronze electrodes today. See your nearest Ampco distributor. Write us for latest Ampco-Trode 10 bulletin giving additional facts.

AMPCO TRADE MARK

Ampco-Trode 10 is a product of

Ampco Metal, Inc.

Department WJ-3 Milwaukee 4, Wis.

W-101

T. S. Long

Resistance Welder Manufacturers' Assoc. at their Annual Meeting, January 16th.

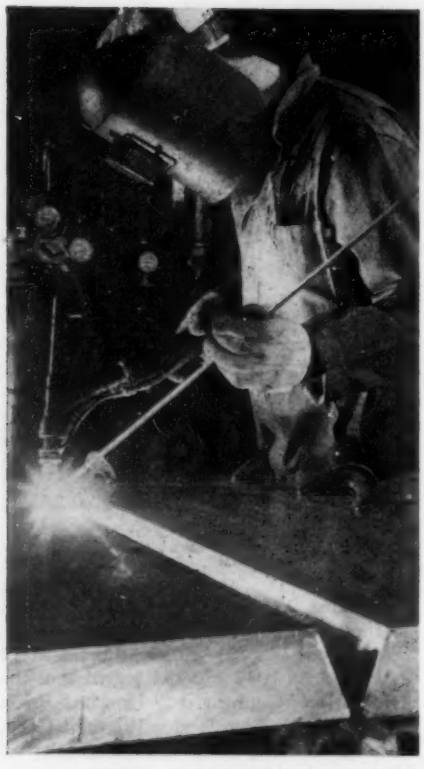
Mr. Long served as Vice-President of R.W.M.A. in 1947 and as Chairman of the Arbitration Committee. He has been affiliated with The Taylor-Winfield Corp. since graduating from the University of Michigan in 1930 and has been active in the work of the Association for several years.

B. L. Wise, newly elected Vice-President of R.W.M.A., has been Chairman of the Association's Technical Committee for the past year. Mr. Wise has been active

B. L. Wise

in the technical phase of the Association's endeavors for several years, contributing largely to the development of Machine Standards published by R.W.M.A., and also to material contained in the Association's "Resistance Welding Manual."

Mr. Wise graduated from Pennsylvania State College in 1933 and is presently on the Board of Directors of the National Electric Welding Machines Co., Bay City, Mich., where he also serves as Director of Production. He is well-known in the welding industry, having served as District Vice-President of the AMERICAN WELDING SOCIETY in 1946 and on various Committees of that organization.



WELDING THICK ALUMINUM

The welding of thick aluminum plate makes feasible the use of this metal in the construction of plants for the production of liquid oxygen. Oxygen is needed in tonnage quantities in the chemical process by which natural gas is converted into gasoline.

Aluminum is one of several materials suitable for the construction of oxygen-processing vessels. It has excellent mechanical properties at the extremely low temperature of liquid oxygen, but inability to weld thick plates of aluminum alloy has stymied design engineers. Battelle technologists have been working on the development of satisfactory techniques for welding thick aluminum in a research investigation sponsored by the Stacey Brothers Gas Construction Co. Among the applicable welding processes which have been used successfully is the argon-shielded tungsten-arc process. The welder in the photograph is joining $2^1/_2$-in. slabs of aluminum alloy, using this process.

AIR REDUCTION ANNOUNCES NEW TECHNICAL SALES APPOINTMENTS

Dr. G. V. Slottman Appointed Technical Assistant to the Vice-President

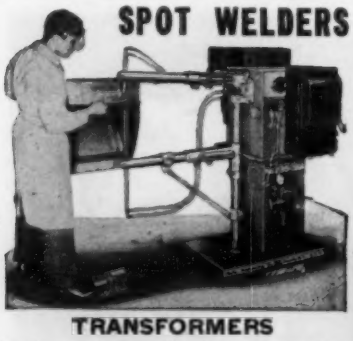
Scott D. Baumer Succeeds as Manager, Technical Sales Division

E. H. Roper Made Assistant Manager, Technical Sales Division

A series of promotions within the ranks of Air Reduction's technical sales personnel were made this week (January 5th) according to an announcement by C. D'W. Gibson, vice-president in charge of sales.

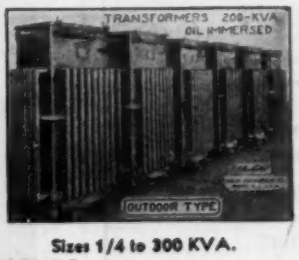
Dr. G. V. Slottman

G. V. Slottman, formerly Manager, Technical Sales Division has been appointed technical assistant to the vice-president. Dr. Slottman, who has been with Air Reduction 12 years holds degrees from Massachusetts Institute of Technology and the University of Berlin. He is a former professor of chemical engineering at M.I.T. and has been closely associated with Air Reduction's development and introduction of steel making processes using large quantity, low-purity



SPOT WELDERS

OF ALL TYPES
SIZES 1/4 TO 300 KVA.
FOR MANUAL, AIR, MOTOR,
OR ELECTRONIC OPERATION.
also BUTT, ARC, and
GUN WELDERS



TRANSFORMERS

For Furnaces, Lighting, Distribution, Power, Auto Phase Changing Welding, and Special Jobs.
AIR OIL, and WATER COOLED.

Sizes 1/4 to 300 KVA.

CHARLES EISLER
EISLER ENGINEERING CO., INC.
779 South 13th St. (Near Avon Ave.) NEWARK 3, N. J., U.S.A.

Time Counts—
Gas cut and Weld with

Shawinigan Carbide

SHAWINIGAN

SHAWINIGAN PRODUCTS CORPORATION
EMPIRE STATE BUILDING, NEW YORK 1, N.Y.

WELDING CONNECTORS

Saxe System Welded Connection Units for welded assembly

Saxe Units place in position and securely hold together structural parts to be welded.

As used in many welded structures they *eliminate all hole punching*, producing an economical, rigid, safe and quickly erected structural frame.

Write for descriptive literature

J. H. Williams & Company
Buffalo 7, New York

G. D. Peters Company
Montreal 2, Canada
Canadian Representatives

NET MONTHLY ADVERTISING RATES
Black and White — **Effective July 11, 1947**

Space	One Insertion	Three Insertions	Six Insertions	Twelve Insertions
*Full page	$185	$165	$150	$140
Two-thirds page	130	120	110	100
Half Page	105	95	85	80
Quarter Page	60	58	55	50
Eighth Page	40	35	30	28
*Inside Preferred	205	185	170	160

10% Extra for bleed full pages. Color $65 extra per color added

Agency Commission —15%
Cash Discount — 2%, 10 days

. . . and a really leak-proof holder, too!

Weiger-Weed Spot Welding Tips give long life, sound, clean welds at lower cost. Standard Weiger-Weed tips in most sizes and shapes—pointed, dome, flat and offset—are available promptly from stock, saving you costly delays involved in producing special tips. Weiger-Weed has electrodes of correct properties for all requirements—spot, seam, flash, butt and projection welding. WW-1 Metal, for example, is best for welding scaly metals, coated metals or aluminum alloys. WW-2 Metal welds cold rolled steel, with fewer dressings, and at top production speed.

Matching WW tips in superior quality, Weiger-Weed has developed a line of trouble-free, water-cooled holders that *positively* and *absolutely* do not leak. *Not one leak has ever been reported!*

Weiger-Weed holders dissipate heat, maintain maximum electrode efficiency and speed up production They are available from stock in straight, offset, universal and close-coupled types for regular and heavy duty service. Handy ejector devices allow quick and easy tip changes.

For sound, practical information on resistance welding, ask for the Weiger-Weed manual. Feel free to use our metallurgical experience and specialized services on any of your resistance welding problems. Weiger-Weed & Company, Division of Fansteel Metallurgical Corporation, 11644 Cloverdale Avenue, Detroit 4, Michigan.

WEIGER-WEED
TRADE MARK
Resistance Welding ELECTRODES
DIES • TIPS • WHEELS • HOLDERS
DIVISION OF FANSTEEL METALLURGICAL CORPORATION

Scott D. Baumer

E. H. Roper

oxygen for both combustion purposes and as a chemical reagent.

In a simultaneous announcement by J. J. Lincoln, Jr., Director of Sales Services, Scott D. Baumer, formerly assistant manager, Technical Sales Division was appointed manager of that division and Edward H. Roper was appointed assistant manager.

Mr. Baumer received his education at Princeton and the University of Pittsburgh. He then spent several years in grey iron and steel foundry production. After 14 years with Bethlehem Steel Co. in both production and maintenance work, he joined Air Reduction in 1941.

Mr. Roper, a graduate of Sheffield Scientific School, Yale University, joined Air Reduction in 1936. After having served in the Applied Engineering Department and the Metropolitan Sales District, he was made assistant to the manager, Technical Sales Division in 1946, a position he held until his recent promotion. Mr. Roper is a licensed professional engineer and has been active for many years in both the AMERICAN WELDING SOCIETY and the International Acetylene Association.

NEW PRODUCTS

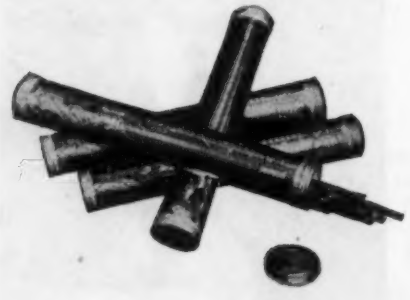
The Society assumes no responsibility for the validity of claims in this section

"HARTOP" HARD-SURFACING ELECTRODES

A new group of hard-surfacing electrodes is announced by Harnischfeger Corp., Milwaukee, manufacturer of P & H welding products.

Named "Hartop" there are four electrodes in this new P & H series: Brown, Green, Red and Yellow. They cover the Rockwell C range of from 35 to 63 (as deposited). Hartop Brown provides a 35 to 40 Rockwell C Hardness and is for welds subject to angular shock and abrasion. Deposits will not chip or spall along edge from glancing blows or sudden loading.

Hartop Green is designed for high resistance to impact and abrasion. It provides strong bonds on carbon and alloy steels, manganese steels and cast iron. Rockwell C Hardness is 45 to 50.



P & H Hartop Red is for severe impact and abrasion and is excellent wearing with high resistance to shattering impact. Rockwell C Hardness is 50 to 55.

The fourth P & H electrode of this new hard-surfacing group is Hartop Yellow with a Rockwell C Hardness of 58 to 63, its deposits resist abrasion and deformation caused by weight and impact.

A feature of all four of these P & H electrodes is their easy, stable arc. Operators do not have to fight to hold an arc; there is no sputtering or hum. Weld metal flows quietly and smoothly. Cleaning of Hartop welds is not required as there is no slag to remove.

With these new electrodes, P & H also introduces a new method of packaging. Each Hartop type is available in specially designed 5-lb. moistureproof tubes having air-tight, screw-on tops. These sturdy containers reduce electrode damage and waste. Full instructions for using each type of Hartop are printed on the tube thereby eliminating the problem of lost procedure sheets.

Complete information on P & H Hartop Hard-Surfacing Electrodes can be obtained by writing Harnischfeger Corp., Welding Div., 4400 W. National Ave., Milwaukee 14, Wis.

METAL SPRAYING

Metallizing without preparation is a fact at last. For years, users of metallizing equipment have wanted to eliminate the elaborate mechanical preparation needed for good metallizing results.

Metco Sprabond is a metal which may be sprayed directly onto smooth, even highly polished steel, and many other materials without any surface preparation.

In building up a worn shaft with metallizing, it used to be necessary to go through at least *eight* different steps. With sprabond, *three* steps are enough. That means a considerable saving in time; a very substantial saving in money.

• For information write Metallizing Engineering Co., Inc., 38-14 30th St., Long Island City 1, N. Y.

HAND TORCH FOR CUTTING STAINLESS STEEL

The Air Reduction Sales Co. has announced the immediate availability of a new hand torch for cutting stainless steel using Airco's Flux-Injection process.

According to the manufacturer, this torch brings economical manual flame cutting of stainless steels within the scope of all types of mill and shop operations.

The new torch, designated in its 21-in. length as Style 9016 is also available in a 36-in. length. Both lengths come with a 90° torch head. This torch, which was subjected to extensive field trial before it was put on the market is similar in many respects to the familiar Airco Series 9000 cutting torch. Specific features of the new torch include:

1. *Monel Metal Head*—means durability—long trouble-free service.
2. *Stainless Steel Tubes*—which provide great rigidity and heat resistance. (This torch has three tubes. The third one carries cutting oxygen and the flux.)
3. *Stainless Steel Lever and Ribbed Handle*—designed to afford maximum ease of operation.
4. *Remote Control Cut-Off*—automatically coordinates the flux feed with the cutting oxygen—eliminates separate flux control.
5. *Uses Standard Cutting Tips*—no special or attachments to buy.

Because of the resemblance in general design between this new torch and the Airco Series 9000, standard parts will very often be adaptable in torch repair, thereby minimizing maintenance costs.

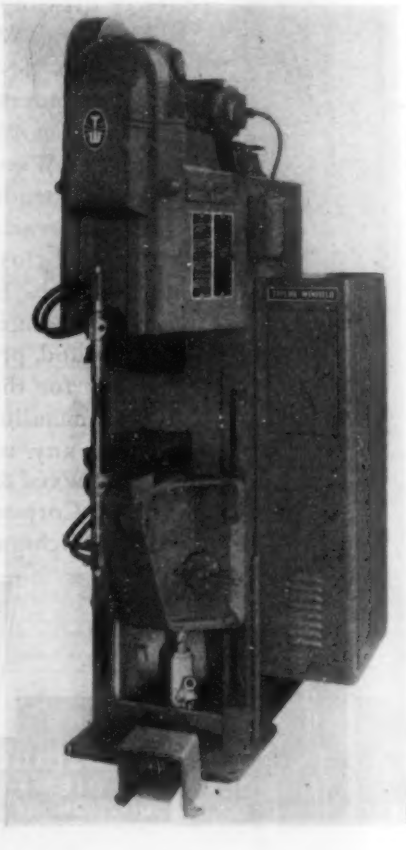
For further information on the new torch or the Flux-Injection process write Dept. 1662, Air Reduction Sales Co., 60 East 42nd St. New York 17, N. Y., or the Airco sales office nearest you.

PRESS TYPE SPOT AND PROJECTION WELDER

The Taylor-Winfield Corp., Warren, Ohio has announced a new Type ENB motor-driven press type spot and projection welder with many improvments.

One of the more important improvements is the adaption of the "production-proved" Roller Anti-Friction head to this welder and the extension of the anti-friction features to include the bellows air lock—optional feature—and bearings for cam follow-up and drive box.

The new cam has been scientifically designed to provide maximum welding force at maximum spots per minute with minimum loading of drive unit. Up to 200 strokes per minute may be had with no alteration to the welder other than changing cams, pulley ratios within the range of $^1/_2$- to 2-in. strokes. The excellent design of this welder permits use of cams calculated to give higher speeds without hammering or defacing the work.



Arc Welding Reduces Warpage ...Saves 50%

BY RAY R. FORSEILLE, VICE PRESIDENT
BALTIMORE AIRCOIL CO., INC.
BALTIMORE, MD.

THE evaporative condensers built in our plant are used in commercial refrigeration and air conditioning systems.

A number of these units, shown in Fig. 1, are ready for shipment to cold storage locker plants. The condenser coil assembly consists of a header plate and tubes. The steel tubes must be welded to the header plate with a pressure type weld capable of withstanding tests of 300 lbs. per square inch of air pressure under water.

The method formerly used to join the condenser tubes to the header plates caused excessive distortion. Converting to arc welding has minimized the warpage well within the limits allowed for the assembly and has netted savings of 50% in this one operation alone.

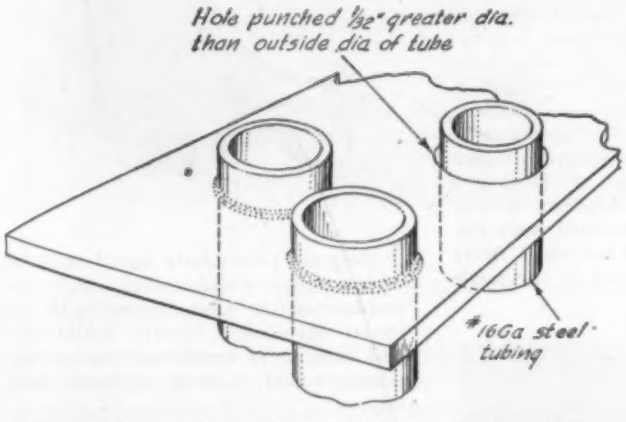


Fig. 2. Pressure weld detail of tubes to header plate.

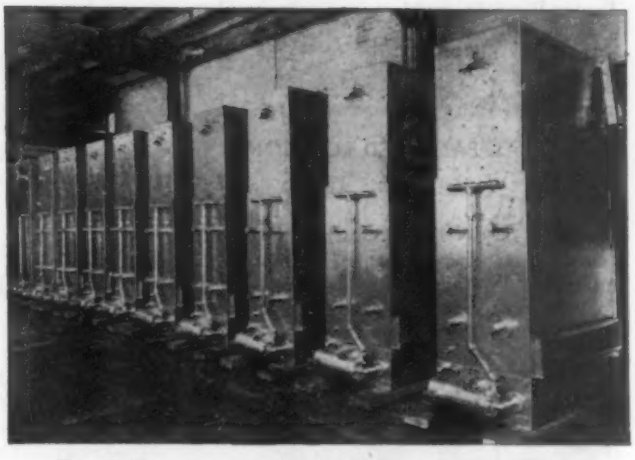


Fig. 1. Ten evaporative condensers representing 400 tube welds.

The holes in the 3/16" thick header plate (Fig. 2) are punched out 1/32" larger than the 1" diameter of the steel condenser tubes, providing a small gap to facilitate getting deeper welding penetration. Arc welding in one pass with 3/32" Lincoln "Planeweld 2" electrode produces a smooth solid weld that enables the assemblies to pass the rigid pressure tests against gas leaks with less than one per cent rejection. "Planeweld 2" has been found exceptionally adaptable for welding the thin wall tubing to the relatively thick metal of the header plate.

The header sub-assemly is built up from fabricated component parts as shown in Fig. 4, Four-inch pipe is flame cut longitudinally to form the header pipe dome to which are welded the end plugs and connector pipes. The sub-assembly is then welded to the header plate with a single pass weld, capable of withstanding the 300-lb. air pressure test.

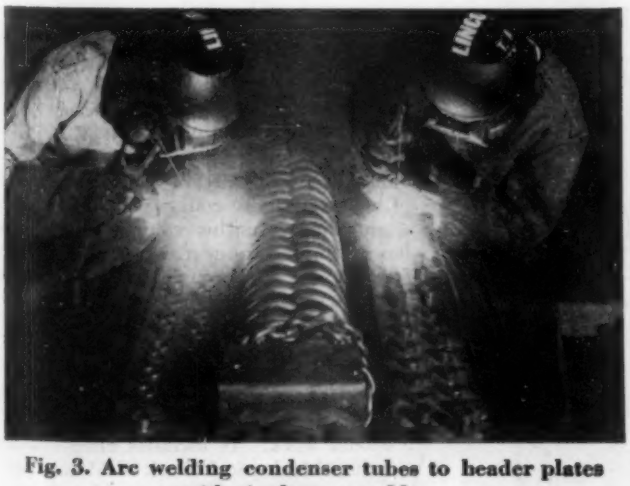


Fig. 3. Arc welding condenser tubes to header plates with single pass welds.

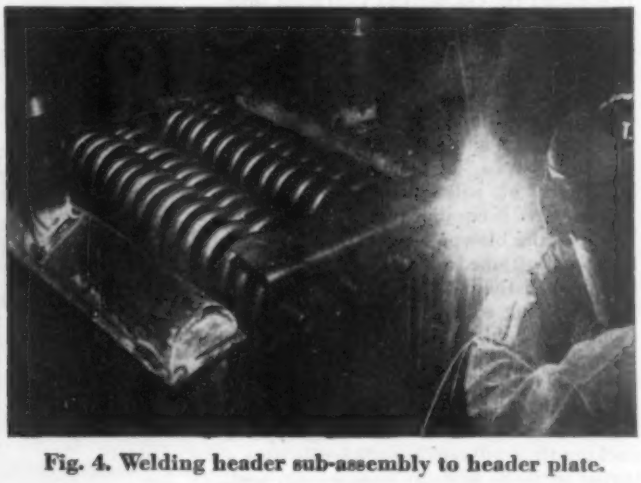


Fig. 4. Welding header sub-assembly to header plate.

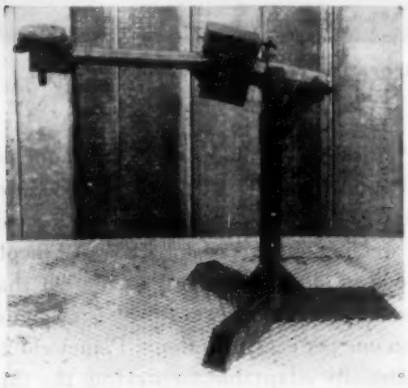
The above is published by LINCOLN ELECTRIC in the interests of progress. For help in design or welding procedure, call the Lincoln Engineer nearby or write The Lincoln Electric Company, Dept. 103, Cleveland 1, Ohio.

None of the original successful features have been dropped in the new design. The transformer is still the rugged Taylor-Winfield "damage resisting" type connected to the tap switches without flexing primary leads. Maximum rigidity for projection welding is assured by the use of composite copper-steel knee construction plus a rugged frame and head support.

All of the optional features common to Taylor-Winfield welders are obtainable with this new design.

UNIVERSAL BALANCED POSITIONER

Aronson Machine Co., Arcade, N.Y. has just brought out Model 14-C500 Quick Adjusting Universal Balanced Positioner. Its quick adjusting feature is ideal for small job shops and where many pieces are added at intervals on a production welding job. Delivery on these machines is two weeks.



EFFICIENT SHUTOFF VALVE FOR OXYACETYLENE PRODUCTION WELDING

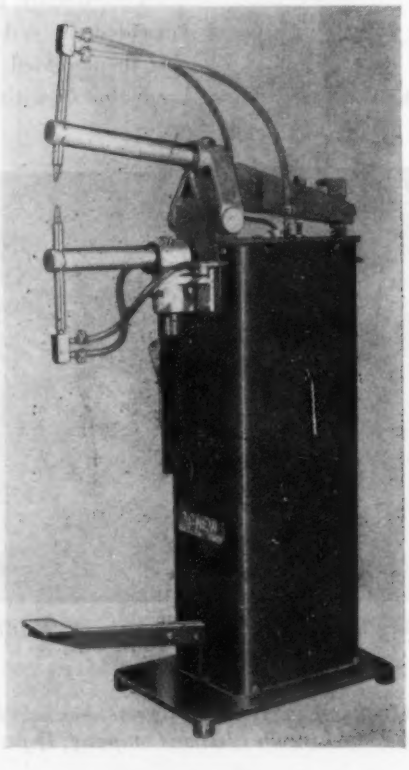
A quick shutoff valve, designed to prevent oxygen and acetylene waste in shops doing production welding, has been developed by The Linde Air Products Co., Unit of Union Carbide and Carbon Corp. It is called the OXWELD V-31 dual shutoff station valve, and when used with the oxyacetylene blowpipe, controls the supply of both oxygen and acetylene or other fuel gas. When welding is interrupted, the operator just hangs the blowpipe on the handy hook, and gas consumption immediately stops. A blowpipe weighing as little as 12 oz. will tightly seal the valve.

The valve is equipped with a pilot light. To light the blowpipe again, the operator lifts the blowpipe from the hook and passes the tip over the pilot light—he is ready to begin welding with the same flame adjustment. The only time the blowpipe valves have to be readjusted is when welding conditions are changed.

The Oxweld V-31 valve is built for hard service and features a self-sealing type of packing that will operate efficiently over a period of years without leakage and with little or no servicing. It is designed for operating pressures up to 100 psi., although it has been tested with pressures much greater than this. Pilot light volume can be adjusted, or completely shut off, by merely turning the pilot mixer. Each valve is supplied with an adjustable base that is easily set for either wall or bench mounting, with the operating lever conveniently placed for hanging up the blowpipe.

FOOT-OPERATED SPOT WELDER

A new foot-operated Spot Welder of the Pivot Type is announced by Agnew Electric Co., Milford, Mich. It is identified as Type "J" and is furnished in 12-, 18-, and 24-in. throat depths with 10-kva. transformer. The transformer, which is glass insulated, has a very short secondary circuit resulting in high efficiency. A four point tap switch is provided with "off" position for set-up purposes and a magnetic contactor and simple automatic switch, designed to pass current only after pressure is applied to the work, is incorporated. The upper and lower horn mechanism is "unit" mounted for rigidity. Both horns are adjustable, in and out, and can be rotated. The lower horn can be swiveled also reversed for getting into deep places. Construction is of fabricated steel with prelubricated bearings at wear points. Machine is furnished with disconnect switch mounted and wired, ready for operation on connection to any single phase a.-c. power supply of 220, 380, 440 or 550 volts, 25, 50 or 60 cycles. Electrical and pressure adjustments are easily accessible from the front of machine which occupies a floor space of 15 × 18 in. plus throat depth. Delivery of the Type "J" machine is from stock.



3 KVA. SPOT WELDER

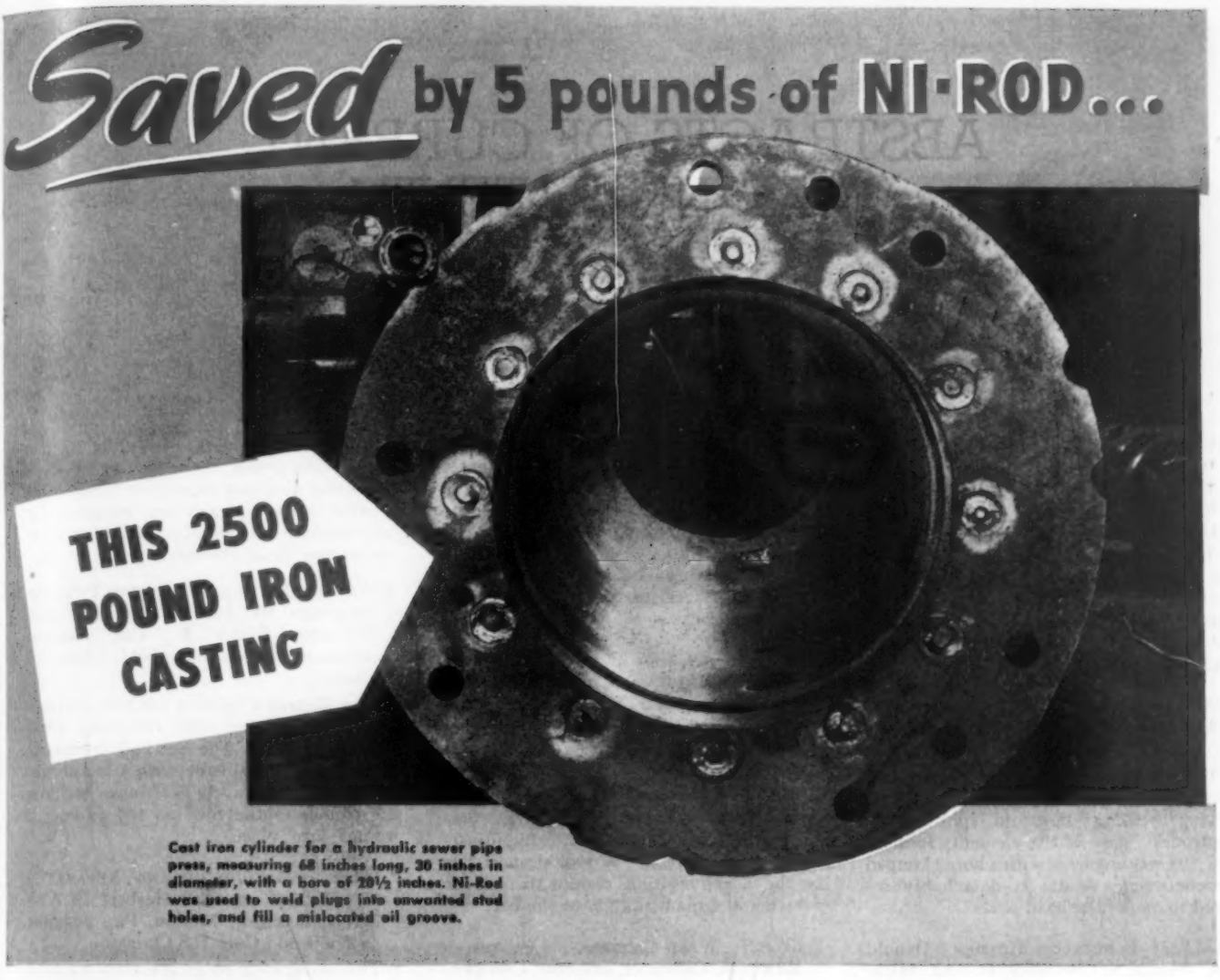
The new 3 kva. Spot Welder by Banner Products Co., 496 North 29th St., Milwaukee 9, Wis., answers the need for a low-cost, versatile air-operated spot welder that is adaptable to many uses. Outstanding features are these: it operates with equal ease in any position—is quickly adjusted to new applications—and being basically simple in design, requires but a minimum of maintenance.

They are particularly suited to setting up in a series—working off of a single timer and foot switch—thus eliminating the high initial investment, costly maintenance and expense of scrapping obsolete units usually found in large multigun installations.

METAL PROCESS ENGINEERING

Metal Process Engineering was written by Norman E. Woldman, Ph.D. and published by Reinhold Publishing Corp., 330 W. 42nd St., New York, N. Y. Price $5.00. The material for this book was accumulated gradually in the development of a postgraduate course in metallurgical engineering. In this volume the author has attempted to meet a growing demand for a short, yet thorough, treatise on various practical phases of metallurgical engineering and metallurgical processes. It was written to meet the needs of engineering students, professional engineers and production men who would use the information in part or as a whole with their professional work. It includes chapters on Casting, Mechanical Work of Metals and Alloys, Forging, Powder Metallurgy, Joining of Metals, Castings vs. Forgings vs. Welds, Heat Treatment, Surface Hardening, Machining of Metals and Tool Steels.

Saved by 5 pounds of NI-ROD...



Cast iron cylinder for a hydraulic sewer pipe press, measuring 68 inches long, 30 inches in diameter, with a bore of 20½ inches. Ni-Rod was used to weld plugs into unwanted stud holes, and fill a mislocated oil groove.

Here is a case where a small dose of Ni-Rod* cured a large technical headache.

When it was discovered that a relatively slight machining error had ruined an expensive 2500 pound casting, technicians of a West Coast machine company were dismayed.

The casting was to be used in a hydraulic press for forming sewer pipes. The mere matter of a mislocated oil groove—measuring only 7 inches long, 2 inches wide, and 1 inch deep—had rendered the cylinder useless for its intended purpose.

Remedies of all kinds were suggested but were regretfully discarded as impractical. When hope of saving the casting by ordinary means had faded, specialists of the Pacific Metals Company, Ltd., Los Angeles, were called in. They were immediately optimistic. They suggested welding with Ni-Rod.

Work was started at once. Welders carefully filled the misplaced oil groove with Ni-Rod. At the same time, still another alteration was attempted. 12 unwanted stud holes were blocked up by welding in cast iron plugs.

When the final remachining was complete, it proved almost impossible to tell where the welding had been done. The repair was successful in every respect, and spirits soared at the machine company's plant. With 5 pounds of Ni-Rod, costing only $7.50, they had saved a 2500 pound casting that had cost $1,000!

Reports such as this—reports of Ni-Rod's superior performance—are coming in from all parts of the nation. Shops everywhere are turning to Ni-Rod for better welds in cast iron, and dependable welds of cast iron to steel. If welding plays a part in your production or maintenance operations, find out more about Ni-Rod without delay. Send for your copy of "For Machinable Welds in Cast Iron." *Reg. U. S. Pat. Off.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

EMBLEM OF SERVICE
INCO NI-ROD TRADE MARK

GET NI-ROD FROM:

Whitehead Metal Products Company, Inc.
Steel Sales Corp. — Williams and Company
Pacific Metals Company, Ltd. — J. M. Tull Metal & Supply Co.
Eagle Metals Co. — Metal Goods Corporation
Robert W. Bartram, Ltd. — Alloy Metal Sales, Ltd.
Wilkinson Company, Ltd. — Metal & Thermit Corporation
Hollup Corporation — National Cylinder Gas Company

ABSTRACTS OF CURRENT WELDING PATENTS

Prepared by V. L. Oldham

Printed copies of patents may be obtained for 25¢ from the Commissioner of Patents, Washington 10, D. C.

2,433,339—Apparatus for Brazing Radially Extending Plates to the Interior of a Tube—William C. Brown, inventor, Watertown, Mass., assignor to Raytheon Mfg. Co. (6 Claims)

The patented apparatus has a cylindrical jig with a longitudinal opening with radially directed slots formed therein. A pair of tapered wedge members are provided for engagement with the longitudinal opening.

2,433,354—Welding Assembly—Joseph A. Fotie, inventor, Kansas City, Mo. (3 Claims)

This patent covers apparatus with upper and lower welding elements for receiving welding dies and spot-welding electrodes. One of the elements forms a two part welding head with a horn clamped therebetween. A die is detachably secured to one of the head parts.

2,433,355—Electrode Holder—Donald A. French, Sr., inventor, Detroit, Mich. (5 Claims)

This holder has a pair of resiliently mounted jaws having tapered shoulder portions, a threaded member to which the jaws are connected, and a tubular handle in threaded engagement with the member and engaged with the shoulders of the jaws to control them.

2,433,610—Water-Cooled Lance Torch—Howard G. Hughey, inventor, Fanwood, N. J., assignor to Air Reduction Co., Inc. (10 Claims)

Hughey's torch has a head positioned within a casing, and a tip operatively associated with the head. Passage means are formed in the head to convey cooling fluid thereto and are adapted to increase the velocity of the circulating fluid in the area of the head which is subjected to the greatest amount of heat when the torch is in operation.

2,433,630—Weld Fabricated Trunnion for Landing Gear Oleos—2,433,631—Weld Fabricated Yoke—Donald W. Sherman, inventor, Shorewood, Wis., assignor to A. O. Smith Corp. (13 and 11 Claims, respectively)

These patents cover two special articles the sections of which are welded together.

2,433,678—Electric Arc Welding—Joseph M. Tyrner, inventor, Englewood, N. J., assignor to Air Reduction Co., Inc. (12 Claims)

Electric welding apparatus includes a source of current, a resistance connected across the source, and a welding circuit connected across the resistance. A second and adjustable resistance is connected to the welding circuit for carrying the current flowing therethrough and the current flowing in the first resistance so that the second resistance can vary the weld conditions.

2,433,734—Means for Supporting Torches in Oxyacetylene Cutting Machines—John Bucko, inventor, Gary, Ind. (3 Claims)

The patented support has a rotatable member for moving a tool in a horizontal plane. A downwardly extending member is secured to an outer portion of the rotatable member and has a vertically adjustable means thereon. A tool support bar on the means positions clamps thereon for rotation in a plane normal to the bar.

2,433,827—Weld-Control System—Edwin M. Callender, inventor, Cynwyd, Pa., assignor to The Budd Co. (11 Claims)

The patented control system has a load circuit and combined lockout and indicating apparatus connected thereto. This apparatus includes a reference circuit having voltage means connected to the load circuit, and a voltage change circuit connected to the reference circuit, which voltage change circuit reflects voltage changes in the load circuit. Power means connect to the voltage change circuit for opening the load circuit and setting up an indication of the degree of voltage change in such circuit, which power means operate on voltage changes in the voltage change circuit.

2,433,963—Weld Testing Apparatus—John P. Tarbox and Edwin M. Callender inventors, Philadelphia, Pa., assignors to The Budd Co. (14 Claims)

This test apparatus detects physical variations in embedded material and it has a source of mechanical vibrations and means through which the vibrations are channeled. Energy for modifying the vibrations is provided and the variations in the vibrations are indicated during the time of variation.

2,433,964—Weld Indicating and Control Apparatus—John P. Tarbox and Edwin M. Callender, inventors, Philadelphia, Pa., assignors to The Budd Co. (14 Claims)

The patent covers a welding system having electrodes for engaging a work piece and disabling means for terminating a weld cycle. Means are provided for preventing repetition of a welding cycle on occurrence of an abnormal weld.

2,433,966—Method of Making Tubular Members by Progressive Helical Welding—Henry P. Van Keuren, inventor, late of Bloomfield, Ohio. (7 Claims)

Van Keuren's welding method provides a tubular member with relatively great radial strength. The method comprises wrapping a metal tube with a metal ribbon, and progressively resistance welding the ribbon to the tube as the ribbon is wound into place.

2,433,967—Method of and Apparatus for Weld Control—Herbert D. Van Sciver, inventor, Merion, Pa., assignor to The Budd Co. (18 Claims)

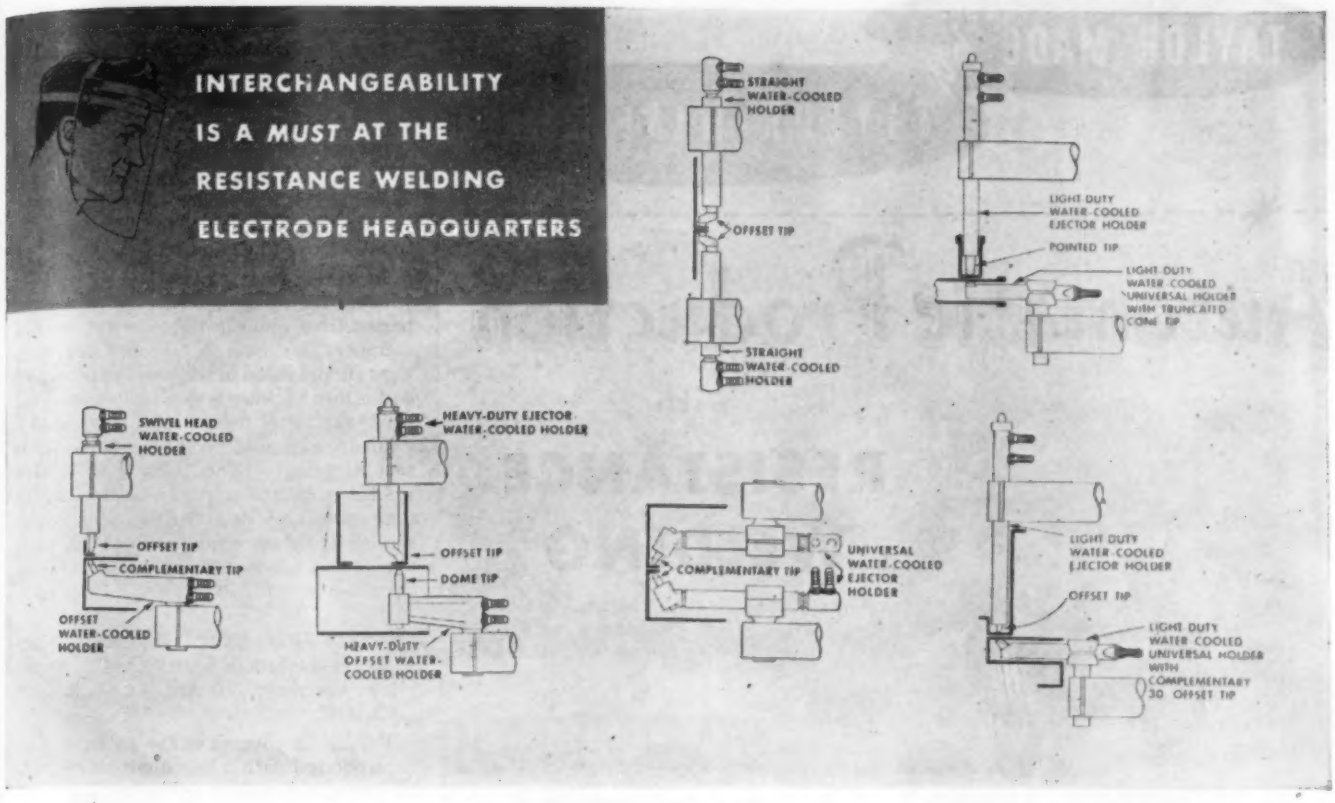
This novel weld method relates to weld control for multiple resistance welding operations. In the method, a welding voltage is applied through a workpiece in a welding circuit having energy controlled means and the voltage is passed through the workpiece until fusion of the material results and produces a substantial percentage voltage change at the weld point. The voltage change is translated into a power manifestation and the power supply is adjusted in accordance with the average time period of energy flow for each weld to the point of the power manifestation.

2,434,023—Electrode Holder for Arc Welders—Ude P. Udesen, inventor, St. Paul, Minn. (2 Claims)

This electrode holder has opposed jaw members with one of the jaws being of circular configuration and the other clamping element having a semispherical member positioned adjacent the first jaw element. Means are provided for clamping the outer ends of the jaw elements together.

2,434,025—Electrode Protector for Welding Machines—Harold E. Wallace, inventor, Kansas City, Mo., assignor to A. F. Parmalee, doing business as United States Safety Service Co., Kansas City, Mo. (4 Claims)

Wallace's protector comprises a shield that circumscribes the end of one electrode. This shield is supported adjacent



The Mallory Line of Tips and Holders

Makes Many "Special" Jobs Standard

First check our new 1948 catalog—

"Mallory Resistance Welding Tips, Holders and Alloys."

It contains everything you want to know about Mallory standardized welding electrodes, holders, replacement parts, accessories, seam welding wheels, dies, and special alloy applications for Resistance Welding.

If it isn't there—get in touch with Mallory direct.

THE MALLORY *Tip, Holder and Alloy Catalog* contains such a diversified line of tips and holders as to make many seemingly complicated "special" jobs simple. Because of the standardization of former "special" items, an ever increasing series of combinations become available. Cost to you, the consumer, is being decreased constantly with the addition of such standard products.

Being the pioneer in the Resistance Welding field of alloys, electrodes and holders has given MALLORY a great wealth of know-how and experience. The complete line of electrodes and holders has been designed for simplification through standardization for an ever-widening range of resistance welding applications.

Whether your needs require standard or special electrodes and holders, MALLORY can be depended upon to supply the best. The ultimate objective of every item supplied is your complete satisfaction.

Before incurring the added time and expense of specifying "special" items, investigate the economies possible by using MALLORY standards. Quality combined with economy are yours when you specify MALLORY.

In the United Kingdom, made and sold by MALLORY METALLURGICAL PRODUCTS, LTD. (An Associate Company of Johnson, Matthey & Co., Limited, Hatton Garden, London, E.C.1.)

P. R. MALLORY & CO. Inc.

MALLORY RESISTANCE WELDING MATERIALS

ELECTRODES—HOLDERS—SPECIAL DIES AND FIXTURES—
ELKONITE* METALS—ALLOY ROD AND BAR STOCK—
FORGINGS—CASTINGS—ACCESSORIES *REG. U. S. PAT. OFF.

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

THE PIONEERS OF ELKONITE*, ELKALOY A*, MALLORY 3*, MALLORY 53B and MALLORY 100 METALS.

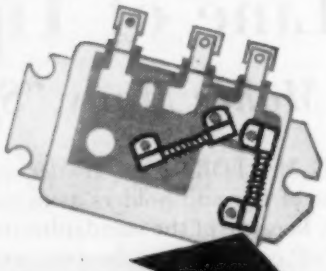
TAYLOR MADE by TAYLOR-WINFIELD

Automatic Production

with

RESISTANCE WELDING

(Left) 10 station, dial feed, T-W Series Projection Welder.
(Below) Voltage regulator sub assembly showing two resistors welded in position.



Up to 7200 Welds Per Hour

THE PRODUCT—Voltage Regulator, sub assembly.

THE PROBLEM—To attach two resistors on under side.

TYPE OF WELDER—10 station, dial feed, double dual head, T-W Series Projection Welder, with automatic mechanical ejector.

PROCEDURE—Operator loads assembly and places resistors in position, then welder takes over. Fingers automatically position parts for welding. After welding, a mechanical pick-off (air cylinder operation) places welded assembly on conveyor belt. Complete operation is automatic from time of loading to ejection.

RESULTS—Production, 7200 welds per hour.—(4 welds simultaneously.)

Our monthly publication "Weld-It" shows many production short cuts by resistance welding. Request it using your company letterhead.

COMMENT—On small or large parts, resistance welding is a fast, sure method of joining metals. Taylor-Winfield makes all sizes and styles of resistance welders, including spot, projection, seam, and flash-butt. If you have a joining problem, T-W can help you.

THE TAYLOR-WINFIELD CORPORATION
WARREN, OHIO, U.S.A.

TAYLOR-WINFIELD
RESISTANCE WELDERS

the electrode end for relative movement longitudinally thereof and is adapted to extend beyond the electrode end when the machine is in an inoperative position.

2,434,321—METHOD OF WELDING—George J. Kleiner, South Milwaukee, and Willerd Schumbacker, West Allis, Wis., inventors, assignors to Allis-Chalmers Mfg. Co. (3 Claims)

In this patent, a method of welding wherein the welding is effected in separate passes from opposite sides of the welding members is covered. Front and back gaps are provided in the parts to be welded and a flux backing is positioned along the back gap after which the front gap is welded and this deposits flux and slag in the back gap. The back gap is then welded while the parts are still at a high temperature so that the flux and slag in the back gap are rendered fluid and leave the parts undamaged and produce an inclusion-free weld.

2,434,343—RESISTANCE WELDING ELECTRODE AND HOLDER—Richard C. Barkelew, inventor, Los Angeles, Calif. (20 Claims)

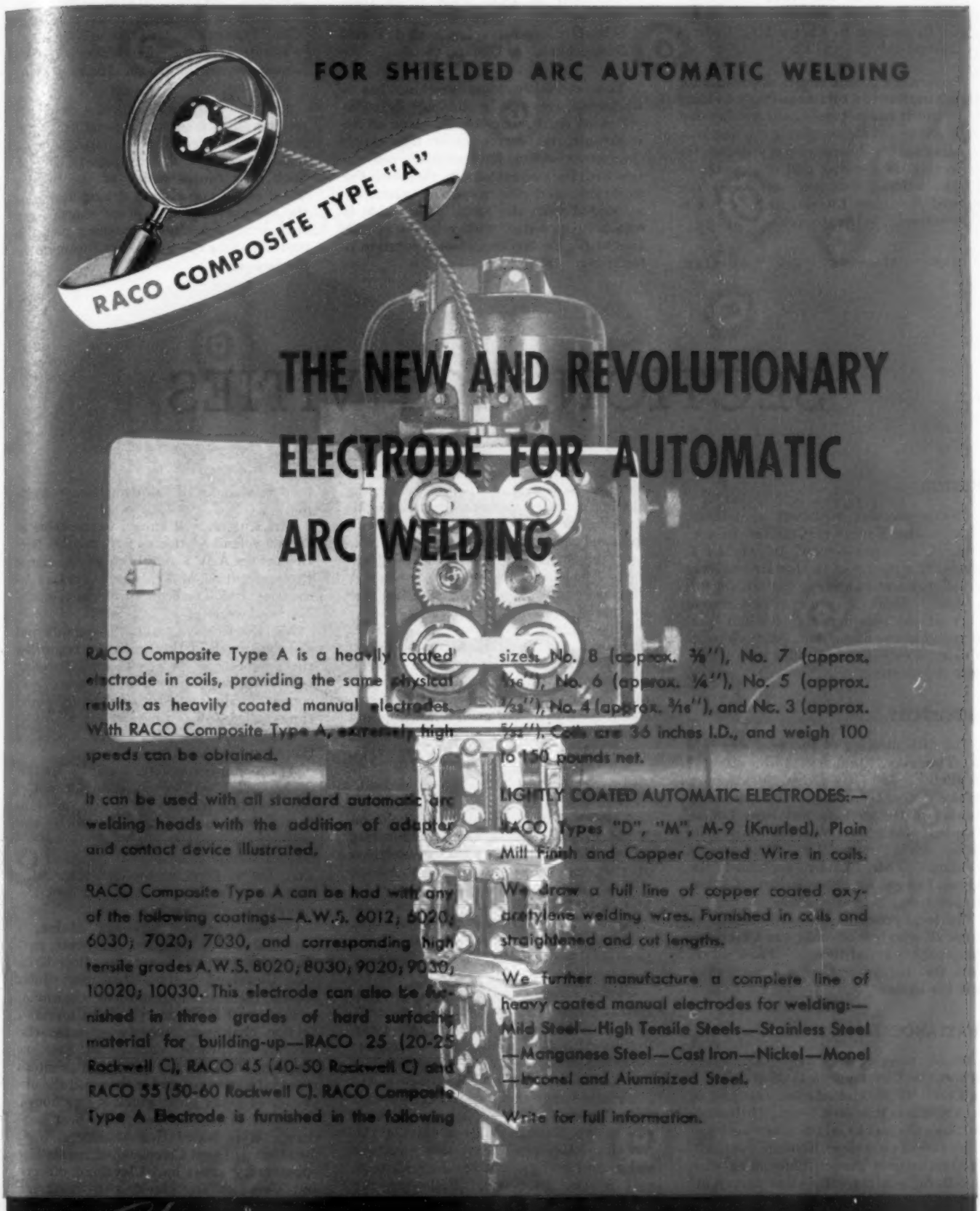
The holder covered in the patent has an electrode rod with a bored out shank, and an elongated holder body with a bore adapted to receive the shank portion of the electrode rod. A coolant duct is provided in the holder and cummunicates with the bored out shank. The electrode rod is clamped in the bore of the holder.

2,434,350—CONTROL UNIT FOR WELDERS—Edward O. Courtemanche, inventor, Rosewille, Mich., assignor to Briggs Mfg. Co. (11 Claims)

Electric welding apparatus including a piston slidably mounted in the cylinder and controlled by a pressure fluid and an electrode, carried by the piston, movable to and from engagement with the work are provided by this patent. A valve controls flow of fluid to the cylinder and a solenoid control is provided for the valve. A manually operable switch is provided in the circuit of the solenoid and a repeat switch is also in the circuit in series relation to the first switch and connected to the source of fluid pressure in advance of the control valve. A repeat valve is located in the fluid connection between the fluid source and repeat switch and has a valve member operated by fluid under control of the control valve.

2,434,351—WELDING DEVICE—Edward O. Courtemanche, inventor, Roseville, Mich., assignor to Briggs Manufacturing Co. (5 Claims)

This welding device includes a cylinder with an electrode carrying piston slidably received therein. A second piston is also slidably received in the cylinder and aids in controlling the movement of the electrode carrying piston. The second piston normally has greater pressure applied thereto and retains the electrode carrying piston in a retracted position, and selectively operable means are provided to relieve the pressure acting on the second piston and permit an increase in length of stroke of the electrode carrying piston.


FOR SHIELDED ARC AUTOMATIC WELDING
RACO COMPOSITE TYPE "A"
THE NEW AND REVOLUTIONARY ELECTRODE FOR AUTOMATIC ARC WELDING
RACO Composite Type A is a heavily coated electrode in coils, providing the same physical results as heavily coated manual electrodes. With RACO Composite Type A, extremely high speeds can be obtained.
It can be used with all standard automatic arc welding heads with the addition of adapter and contact device illustrated.
RACO Composite Type A can be had with any of the following coatings—A.W.S. 6012; 6020; 6030; 7020; 7030, and corresponding high tensile grades A.W.S. 8020; 8030; 9020; 9030; 10020; 10030. This electrode can also be furnished in three grades of hard surfacing material for building-up—RACO 25 (20-25 Rockwell C), RACO 45 (40-50 Rockwell C) and RACO 55 (50-60 Rockwell C). RACO Composite Type A Electrode is furnished in the following sizes: No. 8 (approx. 3/8"), No. 7 (approx. 5/16"), No. 6 (approx. 1/4"), No. 5 (approx. 7/32"), No. 4 (approx. 3/16"), and No. 3 (approx. 5/32"). Coils are 36 inches I.D., and weigh 100 to 150 pounds net.
LIGHTLY COATED AUTOMATIC ELECTRODES:—
RACO Types "D", "M", M-9 (Knurled), Plain Mill Finish and Copper Coated Wire in coils.
We draw a full line of copper coated oxy-acetylene welding wires. Furnished in coils and straightened and cut lengths.
We further manufacture a complete line of heavy coated manual electrodes for welding:—Mild Steel—High Tensile Steels—Stainless Steel—Manganese Steel—Cast Iron—Nickel—Monel—Inconel and Aluminized Steel.
Write for full information.
The REID-AVERY COMPANY
INCORPORATED
DUNDALK • BALTIMORE 22 • MARYLAND
SINCE 1919 PRODUCERS OF ARC WELDING ELECTRODES AND WELDING RODS

2,434,481—SUBMERGED MELT WELDING—Rea V. Anderson, inventor, Los Angeles, Calif., assignor to Rheem Mfg. Co. (8 Claims)

Anderson's patent covers apparatus for supplying flux to a submerged melt welding zone and it has storage means for flux and delivery means for supplying the flux to a welding zone. A separator is provided for collecting unused flux and slag produced in the welding zone and separating the unused flux from the slag, which flux is then returned to the storage means.

2,434,814—MACHINE FOR ELECTRIC WELDING OF DIAL FEET ONTO DIAL PLATES—Jules Schneider and Hans Schneider, inventors, LaChaux de Fonds Switzerland. (3 Claims)

This special welding machine has a worktable, two axially slidable electrodes placed at right angles to the plane of the worktable, and two condensers that have a changeover switch for successive connection with the current supply, then with the worktable and the respective electrode associated with the table. The table is rotatably mounted with relation to the axes of the electrodes and such rotation is limited to 180°.

2,434,867—BRAZING METAL JOINTS PROTECTED BY SODIUM SILICATE BY MEANS OF INDUCTION HEATING—Wallace C. Rudd, inventor, Larchmont, N. Y., assignor to Induction Heating Corp. (1 Claim)

In Rudd's brazing method, a coating of sodium silicate solution is applied to the joint which thereafter is subjected to a high-frequency electromagnetic field. Such field causes fusion of the brazing metal and a consequent drying action on the sodium silicate to form a firm layer that acts to retain the brazing metal in position along the joint after fusion of the brazing metal.

SECTION ACTIVITIES

BOSTON

Dinner meeting was held on January 12th in the Engineers Club of Boston. Prof. E. L. Bartholomew, Jr., of M.I.T. presented a review of the fundamentals of metallurgy and welding in his talk on this subject. There was an attendance of forty at the meeting, six of whom participated in the discussion. Refreshments of cider, doughnuts and coffee were served after the meeting.

BRIDGEPORT

The fifth meeting of the year was held on Thursday, January 15th, at the Candlelite, 246 River St., Bridgeport. Steak dinner preceded the meeting. Speaker of the evening was Bent Laune, president of All State Welding Alloys Co., whose subject was "Low Temperature Welding." Mr. Laune explained the various facts about this relatively new low temperature phase of welding.

The local program committee wishes to thank all who helped make the Christmas Party such a grand success. From all reports this party calls for another before next Christmas.

CHATTANOOGA

Dinner meeting was held on January 16th at the Chattanooga Golf and Country Club. G. S. Mikhalapov, manager of the Apparatus Research Dept., Air Reduction Sales Co., spoke on the major accomplishments of wartime welding research. Mr. Mikhalapov showed films along with his talk on welding. This was a very interesting meeting.

CHICAGO

T. B. Jefferson, editor of the *Welding Engineer*, addressed a joint meeting of the A.W.S. and A.S.M.E. on January 16th. Mr. Jefferson's talk, "What the Future Holds for Welding," was termed by many the most successful sponsored by the Chicago Section in recent years. Mr. Jefferson stressed five points which the welding industry must recognize as roadblocks in the path which leads to welding's universal acceptance: welding vs. riveting; the engineer's and designer's attitudes; the locked-up stress scare; whether welding is a tool or a trade; education for the advancement of welding.

Following Mr. Jefferson's presentation there was an interesting discussion period in which many members took part. Prior to the meeting there was the usual get-together of many members of both societies for a period of good fellowship and dinner at Burke's Grille. Two interesting movies also preceded Mr. Jefferson's talk.

CINCINNATI

A joint dinner meeting was held on Monday, January 12th, at Engineering Society Headquarters, by the local sections of the American Foundrymen's Assoc., A.W.S., and the American Society for Metals. "The Science of Humanics," was presented by R. L. Lee, Employees Co-operative Staff, General Motors Corp., Detroit. A movie, "Years of Progress" was also shown.

Dinner meeting was held on January 27th at Engineering Society Headquarters. A. E. Taylor, Product Engineer, American Rolling Mill Co., spoke on the subject, "Welding of Corrosive Resistant Steels." Lantern slides were shown of the products fabricated from stainless steels. A sound and color film, entitled "Flight to the Sun" was shown through the courtesy of the American Airways. Sixty-two members and guests were present of which six took part in the discussion. Following the regular meeting a Dutch Lunch was held for all members and their guests, at which quite a few informal round-table discussions on the use and welding of stainless steel in industry today was discussed.

CLEVELAND

Arthur N. Kugler of the Technical Sales Division, Air Reduction Sales Co., spoke to the February 11th meeting of the Cleveland Section on "Brazing and Braze Welding."

Mr. Kugler, well known to members of the Cleveland Section as well as other Sections of the A.W.S., has been a specialist in the application of welding to various industries and has been prominent in the National Society.

Mr. Kugler gave an interesting talk and clarified much of the confusion regarding the differences between true brazing (silver brazing, aluminum brazing and copper brazing) and braze welding, sometimes called bronze welding.

His talk was preceded by the Airco motion picture, "No Keener Blade."

At the dinner meeting, David A. Aitken of the Cleveland Electric Illuminating Co. spoke on "Cleveland's Industrial Development" and his talk was followed by the now widely acclaimed new documentary motion picture produced by the March of Time for the Illuminating Company titled "Opportunity—the Story of the Best Location in the Nation."

Cleveland members Frank Maine, a National A.W.S. Director; Ed Scott, past Cleveland Section secretary; Bob Kriz, past Cleveland Section chairman; John Austin, membership committee chairman, and Michael S. Shane, present Cleveland Section chairman, recently attended the meeting of nearby chapter at Erie on January 27th. The Cleveland visitors reported a very enjoyable time and the exchange of many ideas which it was hoped would be of mutual benefit to both sections. It is hoped that nearby A.W.S. members will visit Cleveland whenever the opportunity arises and Cleveland officers and directors are planning to visit all neighboring chapters this year if possible.

COLORADO

Monthly dinner meeting was held on January 13th at the Silver Wing Inn, Denver. Speaker at the technical session was F. A. Rohrman, Exec. Dir., Engr. Experiment Station, University of Colorado, Boulder. Mr. Rohrman's subject was "Corrosion." A film "Solving Corrosion

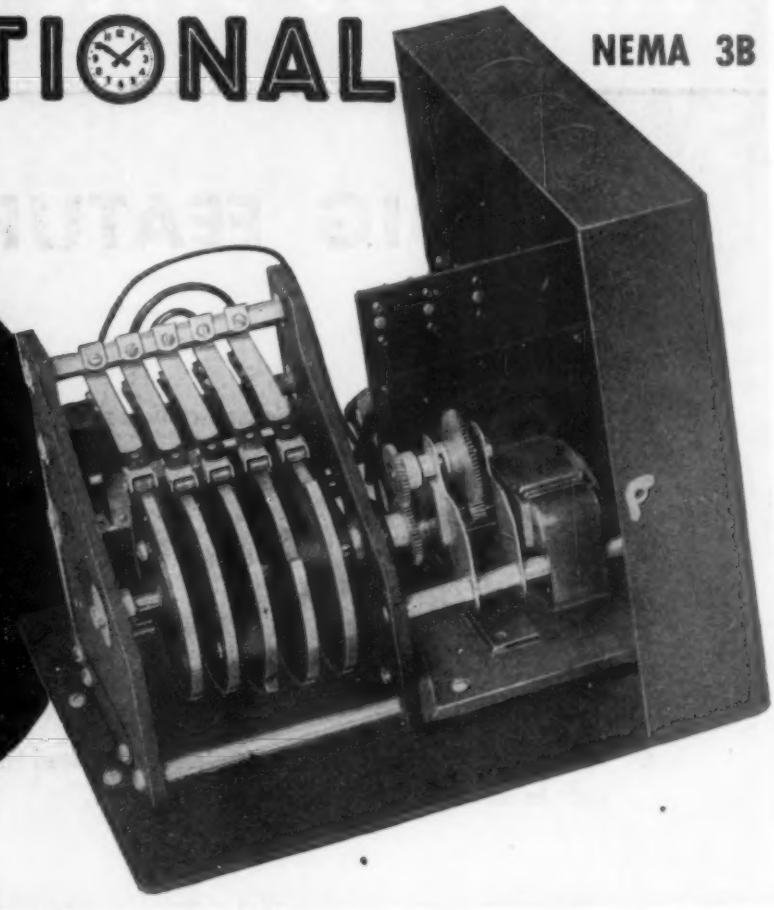
"BEST THERE IS" *by Customer Preference*

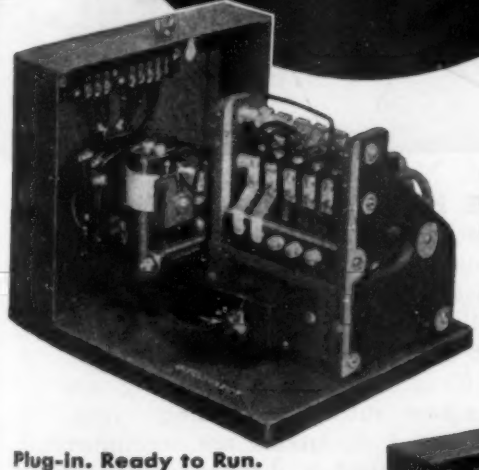
The NEW NATIONAL

NEMA 3B

MODEL 1750 P

WELD TIMER





Plug-in. Ready to Run.

In Mass Production, 'Down-time' is receiving increasing attention. There isn't a machine or tool made, that never needs service. A drill breaks, or a cutter gets dull. A spare takes its place at once, instead of costly 'Down-time', waiting for tool repair.

A spare Timer, that will go into action in a matter of seconds, like insurance, is Protection—'just in case'.

As Production approaches demand, Costs become more Important. $10.00 a year is small enough—but it exceeds the 10 year average parts cost to one customer, using more than 500 National Timers.

The NEW National Timer, equipped with Electro-Dyn non-coasting control, and profiled cams, provides smoother action, even at high speeds. Weld-time consistency within ½ cycle is normal expectancy, when firing Ignitrons directly from timer contacts. National's patented Cam and Contact operation of 'Drop-to-make', followed by 'Drop-to-break', guarantees that accuracy in its simple way.

It is the One timer unaffected by line-surge, relay-lag, moisture, temperature. Choose NATIONAL, and Choose the best.

Plug-out, and Swung-out.
Make adjustments in safety and conveniently, with everything in full view.

All-out.
No wires to Disconnect.
No Main Line to Cut-off.
Simplifies initial Installation, and Regular periodic Inspection later.

NATIONAL TIME & SIGNAL CORPORATION

21800 WYOMING AVENUE DETROIT 20, MICHIGAN

STAINLESS STEEL ELECTRODES...

6 BIG FEATURES

1. Excellent usability characteristics in *all* positions
2. Produces FLAT Fillets
3. Stable arc characteristics permit good directional control
4. Designed for a-c, or reverse-polarity d-c operation
5. Low spatter and easily removable slag
6. Full range of grades and diameters, numbered to AISI code to meet 98% of industry requirements.

ARC-WELDING EQUIPMENT
ELECTRODES and
ACCESSORIES

IF YOU'RE welding stainless, you'll want to try G-E stainless steel electrodes—the first complete line to include improvements growing out of invaluable war production experience.

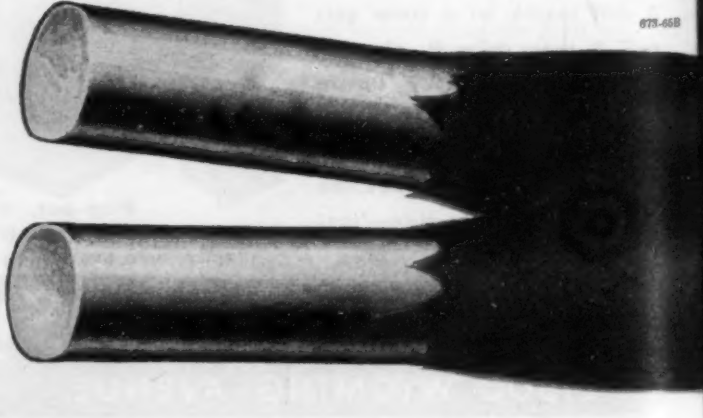
The result of many months of research and development, based upon this war experience, G-E stainless steel electrodes bring to you advantages and features *not heretofore available* in stainless rods.

All 27 types possess excellent usability characteristics in the *vertical and overhead* position as well as the horizontal. Stability of the arc and deposition characteristics have been engineered to assure *flat fillets,* materially reducing grinding time as compared to convex fillets, and reducing the crack-sensitivity at times associated with concave fillets.

Operators of reasonable experience have little difficulty maintaining good directional control of the stable, quiet arc. Two types of flux coatings make it possible to use these electrodes on any current—lime-type for reverse-polarity d-c, and a true Titania type that is equally excellent on either a-c or d-c, and in *any* position. Spatter is extremely low, slag behavior is good, and metal transfer is uniform and easily directed.

G-E stainless electrodes are packed in special cartons, wrapped in water-repellent paper for protection during transit and storage. Ask your G-E Arc-welding Distributor for a copy of bulletin GES-3584.

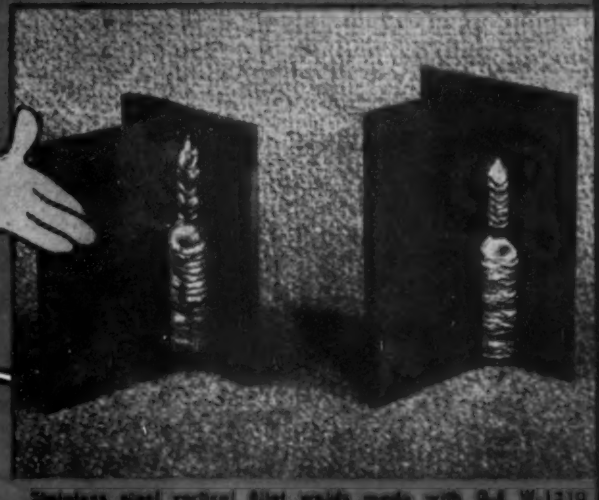
OTHER G-E ELECTRODES—The complete G-E electrode line of some 63 types includes electrodes for special-purpose and alloy welding as well as general-purpose, mild-steel types. Here are just a few of the special types: W-2075 for making machinable welds on cast-iron, W-94 for hard-surfacing applications, W-70 for phosphor-bronze welding; and for *high-speed, uniform* automatic welding, types W-4 and W-1049 coiled electrodes are recommended. Your nearest G-E welding distributor will gladly supply your requirements. *Apparatus Department, General Electric Company, Schenectady 5, N Y.*



27 NEW TYPES...

"Here are a few examples of the swell welding job you can do with these new G-E stainless electrodes! But why not prove it to yourself on some of your own work! Just contact your G-E Welding Distributor."

Copyright 1948, General Electric Company



Stainless steel vertical fillet welds made with G-E W-2310 electrode (left) and W-2310 (a-c or d-c) electrode (right), both 5/32" diameter.

...ess fillet weld made from bottom up with G-E ...310 stainless steel electrode, operating on a-c. ...eration gives identical results.

Stainless steel horizontal fillet weld made with G-E W-2310 electrode operating on a-c. Note the smooth, flat appearance of the fillet.

The 27 types of G-E stainless steel electrodes are identified as follows:

W-1308
W-1309
W-1309Cb
W-1310
W-1310Cb
W-1310Mo
W-1316
W-1316Cb
W-1317
W-1330
W-1347
W-1410
W-1430
W-1446
W-1502
W-1505
W-2308
W-2309
W-2309Cb
W-2310
W-2310Cb
W-2310Mo
W-2316
W-2316Cb
W-2317
W-2330
W-2347

NOTE: The first digit refers to coating, 1 being lime-type and 2 Titania type. The last three digits represent AISI stainless steel code numbers.

GENERAL ELECTRIC

Problems" was shown through the courtesy of the Lukens Steel Co. While the attendance (42) was small, the subject was interesting and all those present had a very interesting evening.

DAYTON

R. T. Gillette, Works Laboratory, General Electric Co., an authority on resistance welding, addressed the Dayton Section in the Spanish Room, Engineers Club, on January 28th. His subject was "Resistance Welding." For the last two decades Mr. Gillette has been following resistance welding research, having transferred to the G-E Works Laboratory development section in 1926. He holds a number of important patents on brazing and welding. A motion picture "This Is Resistance Welding," was shown.

DETROIT

The Detroit Section held its fifth meeting of the season at the Engineering Society of Detroit on Friday evening, January 9th. Subject for the evening was "Maintenance of Welding Equipment." Al Last, Chairman, introduced the speakers who recommended maintenance procedures for the following: "Arc Welding," V. Speck, Welding Engineer, Ford Motor Co.; "Gas Welding," G. E. Phelps, Technical Representative, Air Reduction Sales Co.; "Resistance Welding," F. R. Woodward, Application Engineer, Progressive Welder Co.

A discussion period followed during which many timely maintenance tips were disclosed.

An interesting sound color film was shown on stud welding through the courtesy of the Nelson Stud Welding Corp.

The Detroit Section held a special meeting January 16th at the Detroit Edison Co., Sales Auditorium. R. C. Singleton of the Nelson Stud Welding Corp., gave a very entertaining and enlightening practical demonstration of various applications of stud welding.

INDIANA

January dinner meeting was held on the 23rd at Buckley's Cumberland, Ind. L. K. Stringham, Chief Engineer in Charge of Welding Applications, The Lincoln Electric Co., Cleveland, spoke on the subject "Weld Cracking, Causes and Cures."

LEHIGH VALLEY

New developments in welding were reviewed in a panel discussion Monday, February 2nd, at the Hotel Bethlehem, Bethlehem, Pa. J. R. Fairhurst, Ingersoll-Rand Co., the moderator, introduced the the following Panel members:

H. O. Hill, President, A.W.S., who spoke of work being done in the National Headquarters to standardize welding symbols and set up codes for various industries. He told of the endeavor of Headquarters to help solve welding problems, with information available to members.

Dr. R. D. Stout, Lehigh University, told of the present research program to determine notch sensitivity of steels and the effects of welding on these characteristics.

R. I. Fluck, Bethlehem Steel Co., told of the important development for shop applications, the automatic welding equipment. He described in detail the welding of pressure vessels by use of the submerged arc.

Discussion followed the presentations by the Panel members.

Also present at the meeting was J. G. Magrath, Executive Secretary of the A.W.S.

"My New Hobby—Photography" was discussed by O. E. Charlesworth, at a dinner prior to the technical discussion.

LONG BEACH

The Long Beach Section held its regular monthly meeting on Friday, January 16th, at the club room of the Sarong Cafe, Long Beach.

Frank G. Harkins, Welding Engineer, Solar Aircraft Co., San Diego, Calif., gave a very interesting talk on resistance and fusion welding of various high temperature alloys, illustrated by slides. A picture was also shown on gas welding of stainless steels.

LOS ANGELES

Recent meeting of the Los Angeles Section were as follows.

On Thursday, Nov. 20, 1947, the regular monthly technical meeting was held at Scully's Cafe. The speaker of the evening was C. T. Schweitzer, engineer in charge of pipe fabrication for the Southern California Gas Co. and the Southern Counties Gas Co. of California. Mr. Schweitzer gave a well-illustrated talk on the quality control methods used in fabricating the "Biggest Inch Pipeline."

The December meeting was purely social, consisting of the annual Christmas party which has now become a tradition of the Los Angeles Section.

On Thursday, Jan. 22, 1948, a joint technical meeting of the Los Angeles Section of the A.W.S. and the A.S.M. was held at the Rodger Young Auditorium. Technical Chairman for this meeting was Orrin Andruss, Director of Research and Development, A. O. Smith Corp., Los Angeles. Mr. Andruss introduced the speaker of the evening, Merrill S. Scheil, Director of Metallurgical Research, A. O. Smith Corp., Milwaukee, Wis. Mr. Scheil discussed "The Relation of Heat Treatment to the Welding of Ferrous Metals." The subject was well illustrated by lantern slides and exhibits showing various phases of welding development and production made necessary by the War Production Program of the A. O. Smith Corp. Immediately following the main subject J. J. Chyle, Director of Welding Research, A. O. Smith Corp., assisted Mr. Scheil in conducting a joint discussion and question and answer period.

LOUISVILLE

T. B. Jefferson, editor of the *Welding Engineer*, Chicago, addressed the Louisville Section at a dinner meeting held in the Leather Room of the Seelbach Hotel, January 27th. Mr. Jefferson's subject was "What the Future Holds for Welding."

Mr. Jefferson reviewed briefly the gradual but ever increasing acceptance of welding as a superior means of joining metals. He told many stories of how manufacturers during the war turned to welding as a means of conserving materials and speeding production and had found its use to be far superior to former methods. In many cases jobs vital to the winning of the war were possible only because of the use of welding. A discussion period followed the talk.

MARYLAND

The January meeting of the Maryland Section was held in the Engineers' Club of Baltimore on January 16th. The after-dinner speaker was John Cunningham, president of the Baltimore Ski Club, who presented a short talk on "The History of Skiing," and showed two very interesting reels of color film on skiing and hiking in the New England states. The technical speaker of the evening was Prof. George D. Marshall, Jr., from the Naval Post Graduate School at the U. S. Naval Academy in Annapolis. Mr. Marshall's subject was entitled "Commonly Used Metals Other Than Steel." His talk thoroughly covered the metallurgical conditions involved in the welding of nonferrous metals.

MICHIANA

The Michiana Section held their January meeting in South Bend, Ind., on the 16th, with Jack Menzies, vice-president of the C. E. Phillips Co., Chicago, speaking on the subject of "Hard Facing." He described the four basic types of material, their application and methods of putting them on. The talk started a discussion which lasted for over an hour.

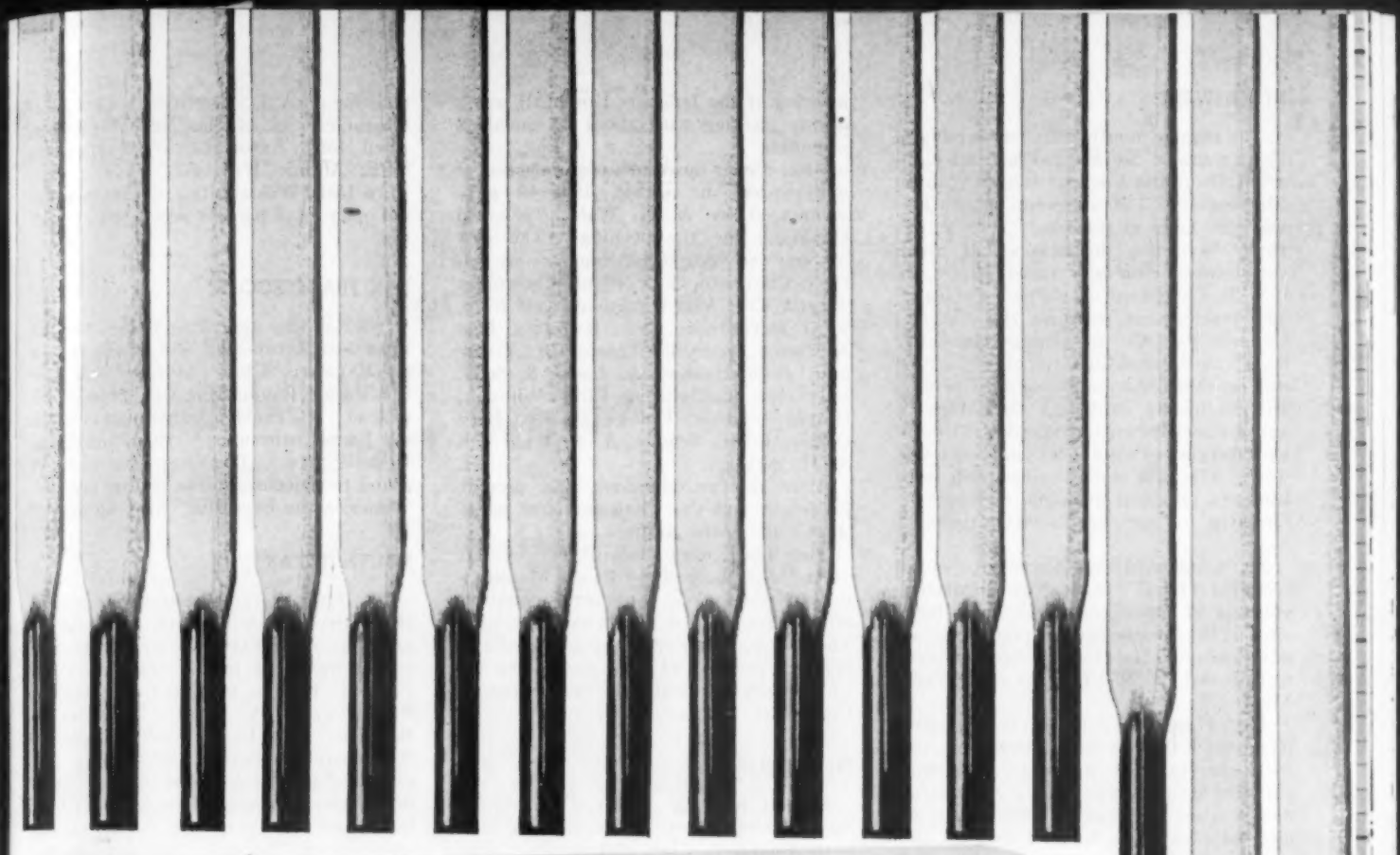
MILWAUKEE

Regular meeting was held on Friday, January 23rd, at the Ambassador Hotel. Dinner preceded the meeting. After-dinner program consisted of sleight of hand by F. E. Garriott, Ampco Metal, Inc. Mr. Garriott was very entertaining with his magic tricks.

The main speaker was Frank McGuire, Jr., Field Engineer, The Linde Air Products Co., whose subject was "Inert Shielded Gas Welding." The program included the presentation of slides and covered the basic principles involved and the primary fields of usage, as well as a description of many practical applications on aluminum, stainless steel and Everdur fabrication.

NEW JERSEY

The regular monthly dinner meeting was held on January 20th at the Hotel Essex House, Newark. A. G. Hogaboom of the Central Technical Dept., Bethlehem Steel Co., Quincy, Mass., addressed a gathering of 120 members and guests, on the increased production through proper choice of welding electrodes and direct or alternating current. A film "Advantages of A.-C. Welding" was shown through the courtesy of the Westinghouse Electric Corp.



These AWS class E-7015, 8015, 9015, and 10015 P&H electrodes take over after conventional electrodes have failed. They —

Handle "difficult" steels with ease —high carbon, alloy, high sulphur, and cold rolled steels — steels that ordinarily can be welded only with high-cost stainless steel electrodes — are easily handled with these reasonably-priced lime ferritic rods.

Also ideal for steel and alloy steel casting repairs — these trouble-saving electrodes produce X-ray perfect welds of high ductility.

Have superior physical qualities — lime ferritics are well suited for welding heavy sections—sections that must withstand severe shock and abuse.

Eliminate preheating — preheating practices generally required to weld high carbon and alloy steels are eliminated with these electrodes — except in the case of heavier sections.

Withstand high amperages and have high deposition rate—Besides taking the heartaches out of handling "hard-to-weld" metals, P&H lime ferritics reduce production time. Your operators burn more pounds per hour with these "hot rods," substantially lowering your welding costs.

Place an order for our lime-ferritic electrodes with your P&H representative or local P&H distributor. See for yourself how these rods solve your difficult welding problems and save you money. Remember, P&H provides America's most complete arc-welding service — there's a money-saving P&H electrode for every welding problem. Write us for bulletin R7-6.

P&H

WELDING ELECTRODES

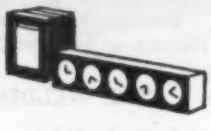
4551 WEST NATIONAL AVENUE
MILWAUKEE 14, WISCONSIN

HARNISCHFEGER CORPORATION

WELDING ELECTRODES • MOTORS • HOISTS P&H ELECTRIC CRANES • ARC WELDERS • EXCAVATORS

Welding Positioners

AC Welders



Welding Production Control Systems

DC Welders

Electric Hoists

NORTHWEST

The regular monthly dinner meeting of the Northwest Section was held on January 12th at the Covered Wagon Cafe in Minneapolis. The National Cylinder Gas Co. were hosts at the usual "Happy Half Hour" preceding the meeting, at which time refreshments were served.

A. F. Chouinard, in charge of research and development work for the National Cylinder Gas Co. of Chicago, spoke at length on "Flame Cutting" and was very well received by an audience of 87 people. He graphically explained all phases of automatic shape cutting and described the various types of equipment used to do this work. His talk and the discussion were kept at a practical level, and was very informative for operators as well as management.

Mr. Chouinard also described a quick "Rule of Thumb" method for calculating volumes of gases consumed for cutting various thicknesses of steel plate. Copies of this formula are available upon request to National Cylinder Gas Co. of St. Paul, Minn.

The "Happy Half Hour" is an experiment which the Northwest Section started with the October meeting. Members gathered around about 6:00 P.M., and, as dinner is not served until 6:30, there is an interval which can be used to good advantage to further good fellowship and acquaintance between members. A host, usually a supplier, is appointed for each meeting. Every member is given two tickets, which entitle him to refreshments. So far the results of this "Happy Half Hour" have been very satisfactory and no doubt the plan will be carried on in succeeding years.

NORTHWESTERN PENNA.

A gala night of fun and fellowship was held on Tuesday, January 27th, at the G. E. Community Center, Erie, Pa. A social half hour was held from 6:00 to 6:30. Dinner at 6:30 P.M. A humorous and instructive talk "Odd Laws in the Statutes" was presented by Robert M. Clemens of Titusville. Mr. Clemens, a distant relative of Mark Twain, is an Engineer at the Process Equipment Division, Struthers-Wells Corp.

The Navy film, "Operation Crossroads," was shown.

A visiting delegation from the Cleveland Section, including James F. Maine, Director at Large, were present.

OKLAHOMA CITY

On the night of Thursday, January 8th, the Oklahoma City Section held its regular Section meeting in the Mirror Room of the Biltmore Hotel. The speaker of the evening was James F. Lincoln of The Lincoln Electric Co. who spoke on the subject of "Incentive for Welding." An excellent attendance of 75 members and guests were present to hear Mr. Lincoln's talk, which was well received and extremely interesting.

PEORIA

On Wednesday, January 21st, the Peoria Section held its annual business meeting at the Jefferson Hotel. It was a dinner meeting with about 45 members attending.

After dinner the results of the election of officers for the season 1948–49 were announced by A. A. Wald, Technical Chairman for the evening. The new officers were introduced and are as follows: Chairman, G. W. Plank, Caterpillar Tractor Co.; Vice-Chairman, Lyle Bibb, R. G. LeTourneau, Inc.; Secretary, Don McCowen, Caterpillar Tractor Co.; Treasurer, John Hanley, A. Lucas & Sons; Executive Committee—Cliff Wimmer, Harold Baldwin, George Deemy, Lary O'Day, Edwin Schmit, A. A. Wald and K. H. Jackson.

After the introductions, the present Chairman and the Chairman-elect made short talks to the group.

Two films were shown, one by Ed Stetzel, Secretary of the Peoria Manufacturers Assoc., who gave a short explanation of the film entitled "Forward America." The film was very interesting and educational. The second film was shown by Cliff Wimmer, member of the Executive Committee.

PHILADELPHIA

A joint meeting with the Society of Naval Architects was held on January 16th at the Engineers' Club, Philadelphia. The subject "Development of Cleavage Fractures in Mild Steels" was presented by Dr. A. B. Bagsar of the Sun Oil Co. Discussors were A. M. Stefano, J. D. Bert, Philadelphia Naval Base and R. D. Bradway, New York Shipbuilding Corp. Coordinator was Harry W. Pierce of the New York Shipbuilding Corp.

PITTSBURGH

The Pittsburgh Section held its January meeting on the 21st in the Mellon Institute, Pittsburgh. Dinner at the Hotel Webster Hall preceded the meeting. Leslie S. McPhee, Whiting Corp., Harvey, Ill., spoke on "Jigs and Fixtures for Welding." Fifty-two members and guests were present.

Attention was called to the Tri-State meeting which will be held on April 30, 1948.

ROCHESTER

Regular montly meeting was held on February 5th. Dinner, cafeteria style, preceded the meeting. The meeting was held in Room 210, Engineering Bldg., University of Rochester. A movie, "Problems in Laying a Transcontinental Pipe Line," was shown, as well as demonstration of Heliarc Welding, by Joseph O'Rorke, Eastman Kodak Co. The equipment loaned by the Eastman Kodak Co., Kodak Park Weld Shop.

The Rochester Section is conducting an educational program, which is being held in the Engineering Bldg., University of Rochester, River Campus, and starts at 7:45 P.M. The first meeting was held on February 19th and consisted of a lecture and demonstration on "Characteristics of D.-C. Electrodes," by Walter Dick.

The remainder of the educational meetings are as follows: March 18th, Characteristics of A.-C. Electrodes; April 1st, Characteristics of the New Electrodes; April 15th, Automatic Welding; April 29th, Atomic Hydrogen Welding; and May 13th, Weldability. These meetings are open to all persons interested in welding.

SAN FRANCISCO

The January dinner meeting of the San Francisco Section was held on the 26th at the Engineers' Club. Milton Forman, of the United Engineering Co., presented a talk on "The Problems in Design of Welding Large Structures." In addition, the United States Treasury Department's sound technicolor motion picture entitled, "America the Beautiful" was shown.

SOUTH TEXAS

The January 19th meeting was held at the University of Houston. Dinner for members of the Executive Committee and guests was held in the Houston Club. James F. Lincoln, president, The Lincoln Electric Co., spoke on the "Incentive for Welding." Mr. Lincoln outlined some of the general applications of welding, and expressed the opinion that progress made in using welding as a tool would have been far greater were it not for the restraining influence of "habit." Mr. Lincoln expressed the opinion that real progress will also result when the ability of the individual is recognized, and he is rewarded for his efforts on the basis of production.

A short address on "A.W.S. Organization and Progress" was made by Howard Simms, vice-President of District No. 6, and was followed by five minutes of legerdemain by South Texas member T. D. Ketchbaw.

SYRACUSE

Leslie S. McPhee, Welding Supervisor of the Whiting Corp. of Harvey, Ill., was the guest speaker at the February 11th meeting held in the Hotel Syracuse. His illustrated talk showed how the Science of Welding has affected the design of heavy special machinery, overhead cranes and foundry equipment fabricated of lead, copper, nickel, Monel, inconel, everdur as well as straight carbon steels by manual and automatic processes.

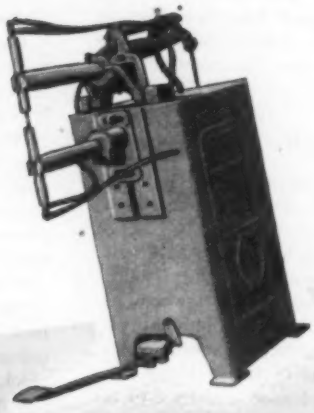
The advantages of arc welding were further illustrated by a sound film by General Electric on "Arc Welding at Work" showing application and economics realized in welding tubing and building construction.

The technical chairman was E. L. Smith of The Lincoln Electric Co., who spoke on "Three Simple Ways to Save by Arc Welding."

WASHINGTON, D. C.

On the 27th of January, the Washington Section enjoyed an interesting and instructive talk by William J. Farrell, Application Engineer of Sciaky Brothers. Mr. Farrell's subject was "Resistance Welding of Heavy Gage Materials." Both the newcomer to resistance welding and the old-timer learned something from Mr. Farrell's talk. He had interesting information for everybody.

Here's the Economical Way to Modernize Your Small Spot Welders



Specify this NEW SQUARE D Combination Control

Single enclosed unit includes timer and contactor—eliminates human element and assures UNIFORM weld quality

Class 8992 Type BBG-1 Controllers (illustrated above) are ideal for small foot-operated or motor-operated welders. A complete line of combination controllers for air-operated machines is also available.

Write Square D Company, 4041 N. Richards Street, Milwaukee 12, Wisconsin, for Bulletin 8992.

• Unit cost and spoilage go down—production goes up, where welding power is controlled automatically. It's a simple matter to modernize old machines with this single device which does the whole job automatically—does it quicker, better, and at low installation cost.

Check your welding equipment with the manufacturer or his representative. You may find that a small investment will bring a substantial improvement in both quality and output.

SQUARE D COMPANY

DETROIT • MILWAUKEE • LOS ANGELES

SQUARE D CANADA, LTD., TORONTO, ONTARIO • SQUARE D de MEXICO, S.A., MEXICO CITY, D.F.

Preceding the meeting, the usual dinner for the speaker was well attended. The Section officers were glad to see new faces among the guests. Everybody is being encouraged to attend the pre-meeting dinners because they afford such an excellent opportunity for the members to get acquainted.

WESTERN MICHIGAN

The second meeting of the 1947–48 season was held on Nov. 10, 1947 at the Association of Commerce Cafeteria. George Sieger, president of S-M-S Corp., Detroit, presented the very interesting film "This Is Resistance Welding" and followed with a lively lecture on both the technical problems of resistance welding and some of the humanistic problems of the welding profession. A highly pleased audience of 80 continued with an excellent thought-provoking discussion on how the profession can meet its future problems.

The "coffee speaker," J. G. Magrath, Executive Secretary of the Society, explained in detail the relationship of Sections to national headquarters, the aims of the national organization and gave helpful suggestions for developing the local Sections as an educational and service organization of the community.

The third meeting was held on December 8th. J. R. Stitt, R. C. Mahon Co., Detroit, presented a slide-illustrated talk on "How Heat Affects Welded Structures." In addition Mr. Stitt gave a most interesting demonstration of his subject by using a torch on straightening and bending various standard steel sections without pressure applied or water quench. An open discussion on the physical principles involved was held during the demonstration. The movie "No Keener Blade" was shown to the audience of 90 members and guests through the courtesy of the local Air Reduction Co. offices.

On Jan. 5, 1948, an additional dinner meeting was held prior to the first plant tour of the season. Members and sponsored guests heard Frank B. Harrington, Resident Plant Manager, Fisher Body Div., General Motors Corp. (Grand Rapids), host for the evening, outline the activities of his plant and the scheduled tour for the evening. Several hours were then spent in a very informative tour of the plant, giving the group the opportunity to observe closely the resistance welding methods of an automobile body manufacturing organization.

WESTERN NEW YORK

The regular monthly meeting of the Western New York Section was held at the University of Buffalo on January 22nd. The usual dinner and social gathering were abandoned in favor of a joint meeting with the Student Engineering Society of the University of Buffalo.

Over 300 members, guests and students were present to hear R. T. Breymeier, Research Engineer, Union Carbide and Carbon Research Laboratories, Inc., Niagara Falls, N. Y., present the story of Inert Gas Arc Welding. Tom presented his subject very ably, using a large number of slides to picture fully each point of the talk with respect to the theory, operation and practical application of the inert gas welding process. The actual function and action of the argon arc were demonstrated clearly in a high-speed movie of Heliarc welding using various materials such as stainless steel, aluminum, etc. The movie was shown through the courtesy of The Linde Air Products Co.

A lively demonstration of the Heliarc welding of aluminum, stainless steel and Everdur preceded the technical session. Most of the various types of electrical equipment, etc., which may be used in conjunction with the welding of metals by inert gas methods, were on display, together with displays of products welded by this process. The products were displayed through the courtesy of 13 manufacturers in the Buffalo district, and included everything from a stainless steel baby incubator to a coin-operated automatic phonograph (61 ST aluminum).

It was gratifying to find that a number of the men at this meeting, as well as at the December meeting, had come a long distance in order to attend. Members and guests were present from the neighboring Canadian cities and from Rochester and Jamestown, N. Y., and Erie, Pa. Every attempt is being made to maintain the interest of these men, as well as those interested in welding from the Buffalo district, and the February meeting should compare favorably with the past meetings.

A. J. Raymo, of the Baldwin Locomotive Works, will be the speaker at the March 25th meeting and will talk on heavy welding with particular reference to locomotive fabrication.

For the April 22nd meeting there will be an actual demonstration and talk on the Nelson stud welder.

WORCESTER

A business meeting of the officers and directors of the Worcester Section was held at Miller & Miller Co., 192 Chandler St., Worcester, Mass., on January 8th.

The regular monthly meeting was held on January 26th at the Svea Gille Club, Shrewsbury, Mass. Arthur R. Lytle, of the Union Carbide and Carbon Research Labs., Niagara Falls, N. Y., was the guest speaker. Mr. Lytle presented an interesting talk and a movie on pressure welding. Samples of work done by this process were also shown. Sixty members and guests were present. Following the meeting, a contest was held using the I. Q. Test set for welders as developed and used by the U. S. Navy. A prize was awarded to the winner who made the highest score.

YORK-CENTRAL PA.

The February meeting was held on the 4th in the Engineering Building, York, Pa. The subject of the meeting was "Safety." J. S. Douglass, of The Linde Air Products Co., Philadelphia, spoke on the subject, "Safe Practices in Oxyacetylene Welding and Cutting."

An added attraction to the meeting was a visit by J. G. Magrath, Executive Secretary.

CANADIAN WELDING SOCIETY

January 7th meeting of the Kitchener-Waterloo Chapter was held at the K-W Y.M.C.A. Auditorium. C. E. Raymond, Welding Engineer, Crane Ltd., Montreal, spoke on the subject, "Design and Fabrication of Pressure Piping."

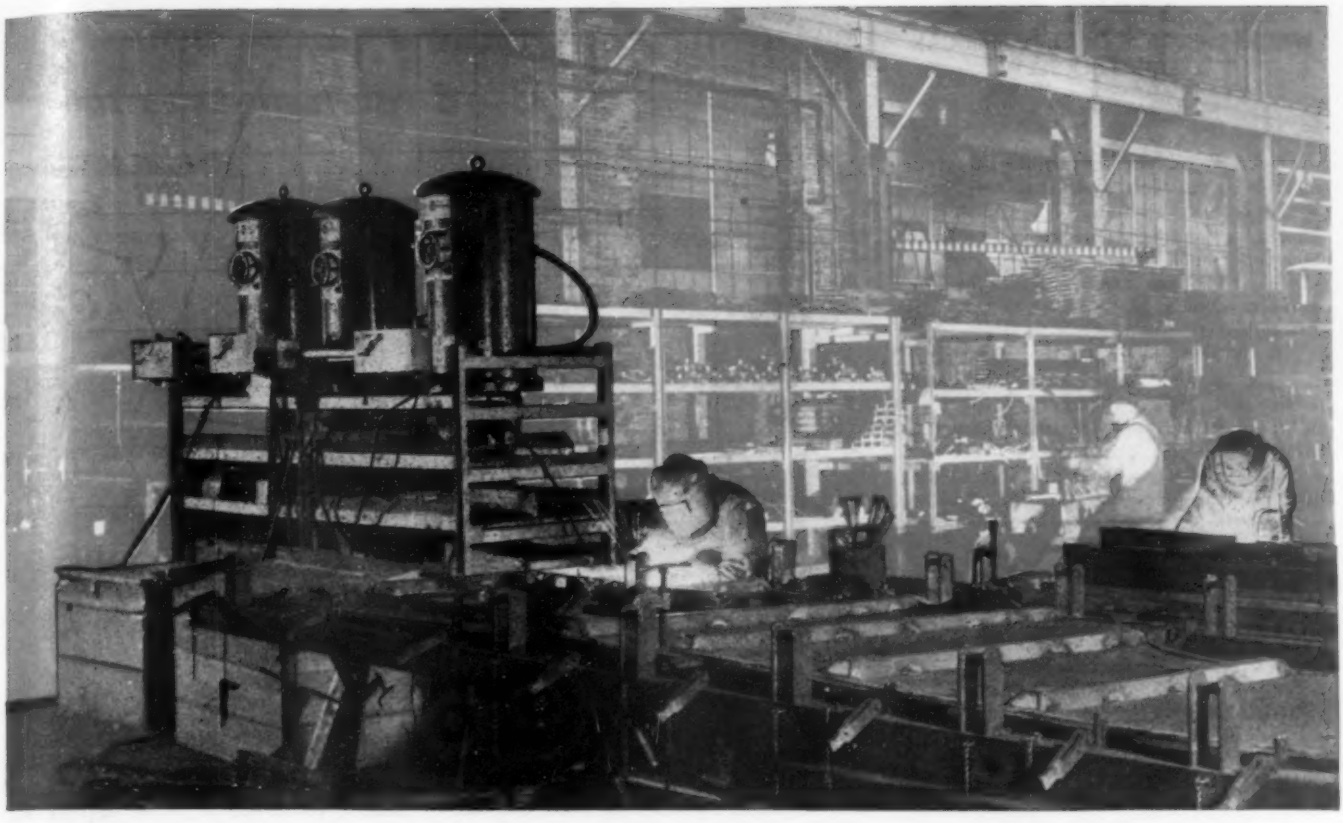
January 16th meeting of the Niagara Peninsula Chapter was held at the Hotel Leonard, St. Catharines. R. A. Dunn, General Sales Manager, Canadian Liquid Air Co. Ltd., Montreal, spoke on "Recent Developments in Welding and Cutting."

January 19th meeting of the Montreal Chapter was held at the Berkeley Hotel. J. Humberstone, vice-president, Arcrods Corp., Sparrows Point, Md., spoke on "The Low Hydrogen Type Electrode."

February 2nd meeting of the Toronto Chapter was held at Malloneys Art Gallery. Foster R. Woodward, Chief Application Engineer, Progressive Welder Co., Detroit, Mich., spoke on, "Selection and Application of Resistance Welding Equipment."

February 3rd meeting of the Hamilton Chapter was held at McMaster University. M. J. Waite, Welding Engineer, Aluminum Laboratories Ltd., Kingston, spoke on, "Aluminum Welding and Brazing."

February 11th meeting of the Niagara District Chapter was held at the Atlas Steels Ltd. Auditorium, Welland. J. J. Kelly, Hamilton District Manager, The Lincoln Electric Co. of Canada Ltd., spoke on "The Welder's Place in Modern Industry."



SMITHway A. C. WELDERS
cover every welding range

The complete line of SMITHway A. C. Welders includes general-purpose models rated at 150, 200, and 250 amperes and heavy-duty models rated at 300, 400, and 500 amperes.

A single convenient hand wheel controls welding current continuously over a wide range, makes desired selection simple, quick, accurate. Sturdy, welded frames assure long, trouble-free service. Heavy-duty coils maintain safe operating temperatures. Insulation is fireproof Fiberglas.

SMITHway Welders eliminate "arc blow." They permit the use of higher currents and larger electrodes. Difficult welds are made faster, easier, and better. Power costs are cut to a minimum. Practically no maintenance is required.

Weatherproof cases of SMITHway Heavy-Duty Welders assure dependable outdoor service in all kinds of weather. Write for complete specifications and prices on SMITHway A. C. Welders, Welding Monitors, and SMITHway *Certified* Welding Electrodes.

SMITHway *Certified* ELECTRODES

Proved in production, they give you better welds at lower welding costs. For all kinds of jobs in all kinds of shops. SMITHway Electrodes are

Made by Welders . . . for Welders

A. O. SMITH Corporation

NEW YORK 17 • PHILADELPHIA 5 • PITTSBURGH 19 • CLEVELAND 4 • ATLANTA 3
CHICAGO 4 • TULSA 3 • MIDLAND 5 • DALLAS 1 • HOUSTON 2 • NEW ORLEANS 18
SEATTLE 1 • SAN FRANCISCO 4 • LOS ANGELES 14
INTERNATIONAL DIVISION: MILWAUKEE 1

A. O. SMITH Corporation, Dept. WJ-348, Milwaukee 1, Wis.
Without obligation, send us specifications and details on:
☐ SMITHway Heavy-duty Welders ☐ SMITHway General-purpose Welders

Name _____ Firm _____

Street _____ City _____ Zone _____ State _____

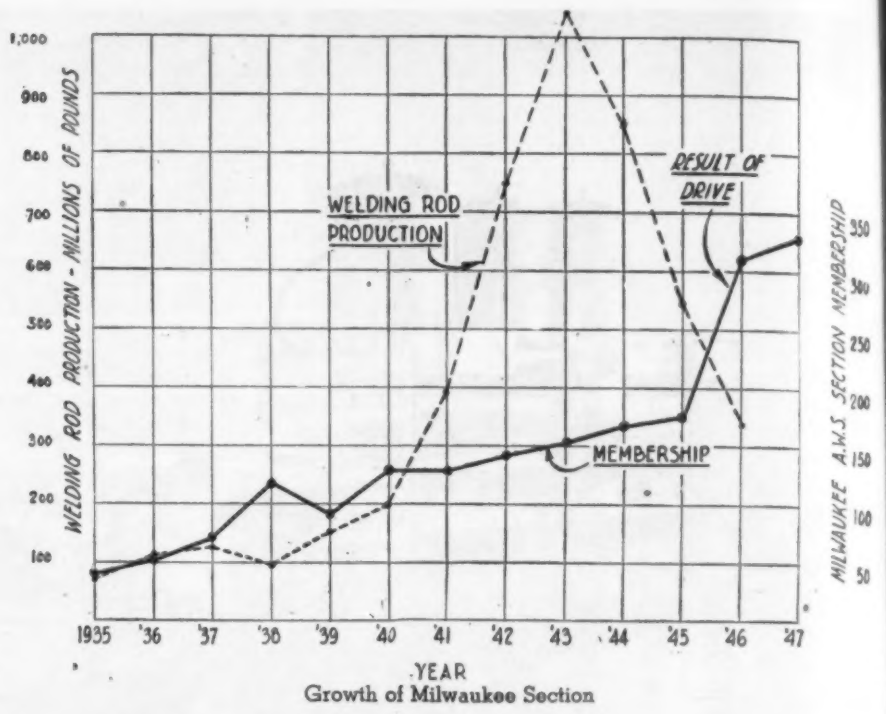
ORIGIN AND HISTORY OF THE MILWAUKEE SECTION OF THE AMERICAN WELDING SOCIETY

By L. E. Grant*

One who for the first time attends a meeting of a section of the AMERICAN WELDING SOCIETY and sees how smoothly affairs are conducted must wonder a little how this comes about and who is responsible. It is obvious that a dinner for fifty or more, followed by a coffee talk and then a technical speaker does not come about by itself; it must be managed. Successful meetings of this type are due to hard work on the part of those members of a section to whom such responsibility is entrusted from year to year. In the same way the very origin of a section is also due to the hard work, vision and enthusiasm of a few who see the need and value of a local organization.

The organization of the Milwaukee Section of the AMERICAN WELDING SOCIETY was due to the efforts of a small group who had foresight enough to see the possibilities and courage to undertake the job. It is probable, too, that in this case at least some feeling of personal convenience played a part. A group, usually consisting of K. L. Hansen, later to become National President of the SOCIETY, John Chyle and L. J. Larson of the A. O. Smith Co., O. C. Voss of Allis-Chalmers, A. T. Meyer of the Heil Co., and R. W. Sternke of Lakeside Bridge and Steel Co. attended meetings of the Chicago Section fairly regularly. While it is only eighty-five miles from Milwaukee and not an abnormally long train ride, yet it made a very long evening for the entire trip. In Milwaukee's winter weather only a genuinely strong desire to attend the meeting was a sufficiently strong motivating force to get a man out. The Chicago Section must have had some very helpful and interesting programs to have attracted these men to their meetings. However, there came a time when the above individuals with a few others apparently decided that the time had come to break away from the Chicago Section and organize one in Milwaukee so that many more people who were interested in welding, but for various reasons did not attend the Chicago meetings very often, could participate in the AMERICAN WELDING SOCIETY.

At a meeting of the Chicago Section held in Milwaukee on Dec. 14, 1934, at the Milwaukee School of Engineering, K. L. Hansen was elected temporary chairman with J. Chyle as temporary secretary to make the necessary arrangements for organizing a regular section of the SOCIETY. These temporary officers appointed a committee to act with them in formulating a set of By-Laws. This committee consisted of the following: R. W. Sternke, Lakeside Bridge and Steel Co.; W. E. Crawford, A. O. Smith Corp.; Otto Voss, Allis-Chalmers Mfg. Co.; A. T. Meyer, Heil Co.; George Johnson, Lincoln Electric Co.; R. E. Boeck, Worden-Allen Co.; and Sam Smith, Air Reduction Sales Co. The committee also acted as a nominating committee and offered the following names for permanent officers: Chairman, Otto Voss; Vice-Chairman, K. L. Hansen; and Secretary, J. J. Chyle.



Growth of Milwaukee Section

The first official meeting of the new section was held on Apr. 18, 1935, and the officers nominated by the committee were elected. The meeting was well attended, indicating a strong interest in and a very real need for a local section. Plans for future meetings were laid and then a talk on "Advances in Machine Construction by Gas Cutting" was presented by R. S. Helmkamp of the Air Reduction Sales Co. As an interesting side light on the technical development that has taken place in the period since the Milwaukee Section was organized, it may be noted that at this first meeting a representative of the United Air Lines exhibited a film called "Across the Continent in Eighteen Hours." At the December 1947 meeting of the section the after-dinner entertainment was a film on "Jet Propulsion for Airplanes." Welding has not only kept pace with airplane development but has helped to make it possible. How, except at meetings of the A.W.S., could an individual keep abreast of the extraordinary progress of the welding industry so easily and completely?

It is of interest to note that a few years later, four to be precise, Mr. Voss' interest in and knowledge of welding and especially the promotion of the use of oxyacetylene equipment were recognized when he was awarded the Moorhead Medal for 1939 by the International Acetylene Association. Very appropriately, Mr. Voss was honored by having the medal presented to him at the Milwaukee meeting in 1940.

The second regular meeting of the Milwaukee Section was held in May 1938 and no further meetings were held until October of that year. In the spring of 1937 K. L. Hanson was elevated to Chairman and Mr. Chyle continued as Secretary. During these formative days of the section the membership numbered around forty, but attendance at the meetings was about the same number indicating interest on the part of some who were not members. Undoubtedly attendance was influenced by the many outstanding speakers which the section was fortunate enough to secure. A list of the speakers almost comprises a roster of men who greatly influenced the course of welding. Such men as J. Owens of the Fairbanks-Morse Co., Prof. W. M. Wilson of the University of Illinois, Dr. S. L. Hoyt now at Battelle Memorial Institute, Prof. Dorrans of the University of Wisconsin. A. E. Gibson of the Wellman Engineering Co. of Cleveland and many others. Membership grew steadily and the section was forced to find a larger and more adequate meeting place so that dinner preceding the meeting could be included in the program of the evening. The programs of the section were not entirely technical as may be seen from the inclusion of the films on airplanes at one of the first meetings. This practice has been continued and many interesting nontechnical coffee talks have been presented after dinner as a regular part of the program. Some of these talks were of sufficient interest to serve as a definite inducement to attend meetings.

In the winter of 1938 it was decided to make the last meeting in the spring a purely social meeting with attendance of wives and other womenfolk of the members. The first social meeting of this type terminated spring meetings of 1938 and was held on June 2nd at the City Club in Milwaukee. Officers for the ensuing year were elected and the balance of a very satisfying evening was spent in dancing and enjoying an entertainment program. The affair was so successful that it has been continued and the last meeting in the spring each year is now regularly set aside for the annual party.

The meetings of the section continued through the war years along the same pattern with no innovations except a number of changes in the meeting place which were necessary to accommodate the larger attendance. In 1945 a number of new ideas were adopted. One of the important developments, because of its financial

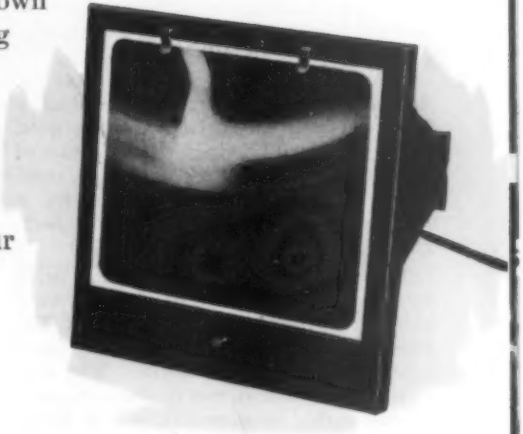
* Chairman, Publicity.

Sound repair welding of castings can be assured

Many faulty castings can be salvaged, made sound, by proper repair welding. How do you assure the soundness of repair welds? By radiographic examination—either by x-ray or gamma-ray (radium) exposure.

. . . when accurate "before-and-after" appraisals are made with radiography

The nature and location of defects are quickly and accurately shown on the radiograph for chipping and welding . . . lack of penetration, gas and slag pockets, or other welding irregularities can be determined after the job is completed. With radiography you can be assured your welds are safe and sound.



For maximum radiographic visibility . . . use Kodak Industrial X-ray Films

Kodak Industrial X-ray Films have the high radiographic sensitivity—the extremely high contrast and fine graininess for the detail visibility necessary in critical radiographic inspection.

. . . they are especially adapted to your requirements

Kodak Industrial X-ray films are designed to meet every normal x-ray requirement:

Type F . . . with calcium tungstate screens—primarily for radiography of heavy steel parts. For the fastest possible radiographic procedure.

Type M . . . first choice in critical inspection of light alloys and in the examination of thin steel at moderate voltages and heavy alloy parts with million-volt equipment.

Type K . . . primarily for gamma and x-ray radiography of heavy steel parts, and of lighter parts at limited voltages where high film speed is needed.

Type A . . . for x-ray and gamma-ray work in sections where fine grain and high contrast are desirable for maximum sensitivity at moderate exposure times.

Eastman Kodak Company
X-ray Division, Rochester 4, N. Y.

"Kodak" is a trade-mark

RADIOGRAPHY

. . . another important function of photography

Kodak

benefits, was the adoption of a policy of presenting to local industrial firms the desirability and value of patron memberships as an aid in conducting the work of the local section. The response to this program was immediate and gratifying. It helped to make it possible for the Milwaukee Section to present an additional service to those interested in welding. This new service consisted of an educational course of five lectures on topics of interest not only to engineers and supervisors but also to operators. The course was open without charge to anyone interested sufficiently to attend. The first educational course was presented in the fall of 1945 and was followed by a similar course in 1946. The response to these courses was much greater than expected, the seating capacity of the lecture room (over 300) at Marquette University being exceeded on a number of occasions. Another course along the same general lines will be given in January and February of 1948.

Another innovation of 1945 was an annual stag and smoker, an informal affair devoted solely to social activities, good fellowship, card playing and a program of entertainment. An excellent lunch, combined with the reliable catalyst for a pleasant evening, good Milwaukee beer, climaxed the event.

In 1946 a successful membership drive was planned and conducted under the very able management of H. D. Reehl of The Linde Air Products Co., assisted by team captains whom he appointed. The first step in the campaign was to send out cards to the entire membership, asking those who were willing to assist in the plan to increase the membership to so indicate. Then a dinner meeting of these individuals was held to organize the program. At this meeting a large scoreboard was provided on which was posted a group of six teams of campaigners. These teams were made up from the list of cards returned and from a group of active members willing to help. Each team had a captain appointed by the chairman. The plan was to conduct a person to person contact with every possible potential member. Only two weeks was allotted so that the entire work could be concentrated into a short period. At the first dinner meeting it was announced that a prize would be awarded to the man who obtained the largest number of new members and also that at the following dinner meeting, on a night later in the first week of the campaign, the three who had at that time obtained the most new members would be awarded prizes. Three dinner meetings were held during the two weeks to stimulate canvassing and to follow the progress of the various teams. Posters advertising the A.W.S. were put on display in many of the local plants, an advertisement was placed in one of the local papers (without any tangible result, however) and the A.W.S. booklets setting forth the advantages of membership in the A.W.S. were widely distributed. As a result of this drive the membership in 1946 was almost doubled and the 1947 membership has increased over 1946.

This drive stemmed from the very obvious interest in welding, as indicated by the attendance at the meetings of many who were not members. The officers of the section felt that many of these men would, if they had presented to them all the advantages of belonging to the section, want to join. That this actually was the case seems to be borne out by the results of the membership campaign. Certainly it is the duty of the local section to make available to all who are interested in welding, complete information as to the advantages to be gained by affiliation with the A.W.S. To assume that the potential members have had the facts presented to them is taking too much for granted. The local section should make it one of its objectives to make sure that the A.W.S. is understood and its objectives appreciated.

In looking back over the steady and satisfactory growth of the Milwaukee Section it appears that this can be explained by a number of influences. It is obvious that an aggressive, interested and unselfish group of officers have played a major role. They are the men who have planned and guided the sections activities on a sound basis. The various men who have been responsible for the speakers have also had a very important part in securing good attendance at meetings. Good speakers are one of the most helpful factors in attracting those who may not be members but who, out of justice to themselves, ought to be. In this connection it is of interest to note that some of the most successful meetings have been those where the speakers have presented their topics in an interesting manner without using highly technical language.

Another factor which has helped the section has been the cooperation of the supply companies. They have contributed support in many ways but have never tried to dominate the section or to dictate policies. Their broad outlook for the ultimate good of the section as well as the interests of welding itself bespeak an enlightened and commendable attitude.

Of course the wide variety of welding industries in the Milwaukee area and the continuous growth of them has also been a very significant factor. Industries here using welding are so varied that to catalog them would be to almost list the major manufacturing fields, but it may be worth while to mention a few; earth moving equipment, cranes, engines of various kinds, heavy machinery, ships, railroad cars, electrical equipment, bridge building boilers, automotive, aluminum utensils, pipe line and many others are all to be found in the Milwaukee area. Such a diversity in industry leads to a diversity of interest and many special problems for the welding engineers and supervisors. A common meeting ground where problems can be discussed with fellow workers and where solutions to problems may be gained from facts presented by informed and experienced speakers is provided by the local section of the AMERICAN WELDING SOCIETY.

That the Milwaukee Section has grown consistently and in line with the development of welding may be seen from Fig. 1, showing the membership growth during the past 12 years and also the sale of welding rods by pounds for the same period except 1947. The war years naturally show an abnormal condition for the sale of welding rod, but it is probably just as well that the membership did not fluctuate in the same manner. The result of the membership drive in 1946 is very obvious in the graph.

The officers of the Milwaukee Section from the beginning to date are listed below:

	Chairman	Vice-Chairman	Secretary-Treasurer
1936	Otto Voss	K. L. Hansen	J. J. Chyle
1937	K. L. Hansen	H. F. Falk	J. J. Chyle
1938	J. G. Shodron	J. J. Chyle	G. F. Meyer
1939	R. W. Sternke	R. E. Boeck	G. F. Meyer
1940	R. E. Boeck	J. J. Chyle	G. F. Meyer
1941	J. J. Chyle	K. Walker	G. F. Meyer
1942	K. Walker	E. C. Brekelbaum	G. F. Meyer
1943	E. C. Brekelbaum	C. Malmberg	G. F. Meyer
1944	C. Malmberg	G. F. Meyer	C. Hart
1945	G. F. Meyer	J. B. Welch	C. Hart
1946	J. B. Welch	H. E. Bailie	C. Hart
1947	H. E. Bailie	C. Hart	R. P. Walbridge

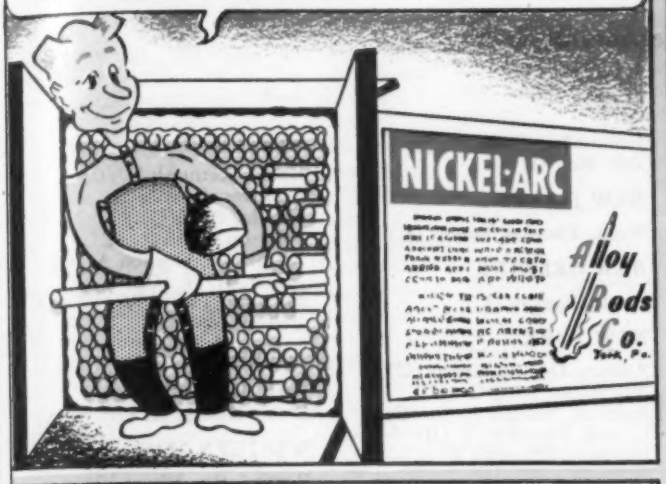
ANNUAL MEETING

PHILADELPHIA—WEEK OF OCT. 24th

Welding Exposition—Symposium, Research Papers, Articles on How to do it,
Design & Applications

SPARKY "tells all" about NICKEL-ARC

MEET MY FAVORITE ELECTRODE FOR AC OR DC CAST IRON WELDING. IT COMES IN THIS HANDY 10 LB. PACKAGE.



WATCH HOW NICKEL-ARC MAKES THIS CRACKED CASTING GOOD AS NEW . . . FIRST, I OPEN UP THE CRACK . . .

DIRT AND GREASE REMOVED — NOW THE CASTING IS READY TO WELD. THERE'S NO PRE- HEATING WITH NICKEL-ARC.

SMOOTH-RUNNING? YOU BET! AND THERE ARE NO INJURIOUS OR HARMFUL GASES TO WORRY ABOUT.

HERE'S THE PAY-OFF. THE NICKEL-ARC DEPOSIT IS A CINCH TO MACHINE — AND COMPLETELY FREE OF POROSITY.

PERFECT COLOR MATCH, TOO. YEP, NICKEL-ARC'S WELD DEPOSIT MATCHES PERFECTLY THE COLOR OF THE PARENT METAL.

For samples, see your distributor or write Alloy Rods Company, York, Pa.

List of New Members

January 1 to January 31, 1948

BIRMINGHAM

Colbert, W. D. (C)
Douglass, H. E. (C)
George, S. L. (C)
Harris, L. J. (C)
McDonald, F. W. (C)
Parker, J. C. (C)

BOSTON

Briley, E. D. (C)

CHATTANOOGA

Wall, Lewayne N. (C)

CHICAGO

Tracy, Stark E. (C)
York, James T. (C)

CINCINNATI

Webster, Francis L. (C)

CLEVELAND

Albert, Drexel R. (C)
Ashton, Theodore (C)
Jerabek, Paul E. (B)
Kaiser, William A. (C)
Plummer, Elias J. (C)
Plummer, James F. (C)
Plummer, Richard H. (C)
Spain, John R. (C)
Thayer, Edward K. (C)

COLUMBUS

Christin, R. Ernest (C)
Clapp, Melvin C. (D)
Ebert, Harry W. (D)
Harwart, Edward A. (D)
Jain, Shantilal J. (D)
Lincoln, John G., Jr. (C)
McGehee, Paul W. (C)
Meyer, Amel R. (C)
Morrison, Warren D. (D)
Williams, Arthur J., Jr. (C)

DETROIT

Fisher, Avery H. (B)
James, Herbert C. (B)
Reed, Edwin B. (B)
Reynolds, Richard K. (B)
Strother, Porter (C)

HARTFORD

Entwistle, Herbert (B)
Gross, Royce L. (B)
McIntyre, Norman (B)
Risch, Theodore A. (B)
Schleifer, Sam (B)

INDIANA

Waddell, Ernest H. (D)

IRLAND EMPIRE

Nixon, O. L. (B)

LEHIGH VALLEY

Dunn, Charles W. (C)
Gordon, Paul F. (C)

LONG BEACH

Butler, Rollo Algie (C)

LOS ANGELES

Anderson Paul Z. (C)
Baird, Bruce C. (C)
Pinchev, Julius A. (C)
Walker, Jason H. (C)

MARYLAND

Albrecht, Fritz (B)
Knox, Fred V. (B)
Lawrence, W. L. (C)
Saas, John A.

MICHIANA

Hosterman, James F. (C)

MILWAUKEE

Awe, Louis (C)
Davis, Robert (C)
Frey, Muir Luken (C)
Zeh, Ray (C)

NEW JERSEY

Scala, Thomas Tobias (C)

NEW ORLEANS

Wade, Earl F. (C)

NEW YORK

Adams, Donald Evans (C)
Hotchkiss, John G. (C)
Johnson, Harold I., Jr. (C)
Leston, Theodore I. (B)
Petersen, Franklin V. (C)

NORTHERN NEW YORK

Pfluger, Allan R. (D)

NORTHWEST

Kline, Stanley M. (C)

NORTHWESTERN PA.

Kinghorn, Talman H. (C)
Merz, William F. (C)
O'Kelly, Kent P. (C)
Patterson, Archie A. (C)

PHILADELPHIA

Olsen, Roy Joseph (C)

PITTSBURGH

Holliday, Robert L. (C)
Nesbitt, Lloyd C. (B)

PUGET SOUND

Burwell, Robert W. (C)
Synder, William A. (B)

ST. LOUIS

Lewis, Harvey H. (C)

SOUTH TEXAS

Juergens, W. A. (B)

SYRACUSE

Clark, Kenneth V. (C)
Conover, S. W. (C)
Dilella, Paul (C)
Johnson, Leon R. (C)
Kazanjian, Gordon A. (C)
Miller, R. H. (C)
Murphy, James W. (C)
Nelson, R. B. (C)

TOLEDO

Lark, Edward F. (C)
Licht, George K. (B)

WESTERN MASS.

Barthelette, Albert (C)
Witkop, Gerald V. (C)

WESTERN MICH.

Case, Archie B. (C)
Davis, Thomas (C)
Dunaway, Gordon (C)
Kenney, Robert (C)
Kline, Robert E. (C)
Martin, Elmer (C)
McConnell, Harold (C)
Mitchell, John (C)
Nightingale, Earnest (C)
Schray, Walter (C)
Vandervoort, John (C)
Van Loo, Carl (C)
Veniace, Frank (C)

WESTERN NEW YORK

Grishkat, Herman
Ponkow, John E. (B)

WORCESTER

Foberg, William M. (C)

NOT IN SECTIONS

Chen, Jessy (C)
De Carriere, A. A. (C)
Fjelle, Bjorn J. (B)
Harrington, E. W. (C)
Stotts, Bert E. (C)
Underwood, V. L. (C)

RADIOGRAPH COMPETITION

In conjunction with the photographic exhibit which has become a regular feature of A.S.T.M. Annual Meetings, this year there will be a radiographic section to be sponsored by Committee E-7 on Radiographic Testing.

The exhibit as a whole will be used to show how radiography has been used in recording details of internal structure, relative arrangement of inaccessible parts, clearances, etc., of both weldments and castings. All radiographs submitted for the exhibit will be judged on a competitive basis by a special Subcommittee of E-7.

Films for submission and any question about the exhibit should be addressed to D. M. McCutcheon, Ford Motor Co., Chemical Engineering Dept., Rouge Plant, Dearborn, Mich.

IRON & STEEL EXPOSITION

The Iron and Steel Exposition will be held in Cleveland Public Auditorium, Cleveland, Ohio, Sept. 28-30 and Oct. 1, 1948. Heavy demand for exhibit space by exhibitors has now brought reservations to 169 booths.

The biennial exposition is held in conjunction with the annual convention of the Association of Iron and Steel Engineers. A vertical attendance of iron and steel and allied industries' personnel is assured exhibitors. Total attendance at 1946 convention and exposition exceeded 11,000 persons. Membership in the A.I.S.E. is composed of steel mill operating supervisory personnel and engineers. All divisions of the industry are included.

The Cleveland convention bureau has assured 2200 hotel rooms for this convention. Reservations sent directly to hotels will be honored. If the chosen hotel does not have desired accommodations, the reservation will be made by the Cleveland convention bureau in a hotel with accommodations similar to the requested reservations.

Details on the A.I.S.E. convention technical program will be released through technical channels after July 1, 1948.

It is expected that the Arena and Exhibit Halls of the Auditorium will be completely sold out by August 1. Space reservations should be sent to A.I.S.E., 1010 Empire Bldg., Pittsburgh 22, Pa.

Employment Service Bulletin

SERVICES AVAILABLE

A-558. Welder desires position. Am 32 years of age. Have had five years experience as welder. Can give references from former employers. Free to travel. Prefer to work in South.

A-559. Resistance Welding Engineer desires position in either manufacturing or research, location immaterial. Electrical Engineer, wide field of experience obtained in 8 years on production, design, research and electronic control circuits; including experience in manual, automatic arc and stud welding. Further details sent on request.

A-560. Research Metallurgist with excellent background in all welding processes, heat treatment and new alloy development desires position with responsible concern. Wide experience in foundry, metallography, physical testing and thermal analysis. Author numerous technical articles.

BULLETINS ON ALUMINUM BRONZE COLD HEADING ALLOY

Ampcoloy 49, a new aluminum bronze cold heading alloy, is fully described in a new Bulletin 88 just issued by Ampco Metal, Inc., Milwaukee 4, Wis. This new alloy is available both as rod and wire.

It was developed in the Ampco research laboratories to meet the demands of plant engineers who needed an aluminum bronze alloy that could be cold headed.

Made by the extrusion process, the new alloy as produced combines the production economies of cold working, the basic advantages of aluminum bronze and the superior grain structure of the extrusion process.

The new bulletin contains chemical composition, physical properties, sizes and weights, tolerance and suggested uses. It is well illustrated. Copies will be sent on request.

SUSTAINING MEMBER

Brown, Boveri & Company, Baden, Switzerland

In the Thermal machine department, steam turbines including the necessary accessories such as condensers, water and oil coolers are manufactured. Also Velox steam generators, electric boilers, water separators and superheaters, together with the necessary steam piping; gas turbines, blowers, compressors and gearing.

The machine factory manufactures large and small generators, motors, transformers, mutators, welding transformers and equipment for electric locomotives and trams.

The apparatus factory produces switch and control gear, remote control systems, air-and oil circuit-breakers, disconnecting switches and switchgear for high and low voltages, etc.

NEW RESISTANCE WELDING CATALOG

P. R. Mallory & Co., Inc., Indianapolis, Ind., announces publication of a new catalog describing the Mallory line of resistance welding tips, holders and alloys.

The catalog contains 40 pages and cover, is profusely illustrated and replete with diagrammatic and specification chart material. Printed in two colors throughout on heavy coated stock and having a three-color cover, the new catalog is one of the handsomest in the Mallory series.

Among the special features of the new edition is a section describing the physical and mechanical properties of the eight Mallory special electrode alloys and the Mallory Elkonite line, along with their specific applications in resistance welding. Accompanying this is an ingenious chart showing the "Recommended Electrode Materials" for spot welding similar and dissimilar metals.

The major part of the catalog is devoted to the big Mallory line of welding tips and holders and accessories and the dies and fixtures used in flash, butt and projection welding operations, as well as seam welding wheels and shafts and bushings for this process. Every item is handsomely illustrated and diagrammed with appropriate measurement specifications.

Mallory's special Resistance Welding Design and Engineering Service is described in the final section.

Requests for the Mallory Resistance Welding Catalog may be directed to P. R. Mallory & Co., Inc., 3029 E. Washington St., Indianapolis 6, Ind.

INDUSTRIAL WELD REPAIR

Simplified welding technique for maintenance and repair of a wide variety of metals, forms, castings, shapes and heavy machinery components are set forth in a new 4-page bulletin recently issued by Eutectic Welding Alloys Corp., 40 Worth St., New York.

Specialized methods, which involve welds made below base metal heat of fusion through surface alloying, are described in considerable detail for major industrial alloys from which equipment is fabricated today.

Photographs and diagrams illustrate typical step-by-step operation, when welding spring bases, axles, journals, motor blocks, impellers, malleable and cast-iron parts. Brief case histories reflect maintenance problems of heavy, rather than light industry, with samples selected mainly from transport and allied fields.

Ask for Eutectic's Railroad Salvage Bulletin "R."

TUBE-TURN FITTINGS

The *Tube-Turn Catalog and Engineering Data Book No. 111*, which has come to be regarded as the "bible" on the subject of welding fittings and flanges for industrial piping, now has a 20-page supplement.

The supplement is devoted to specifications that cover new items in the continually expanding line of Tube-Turn fittings. It is 6 x 9 in. and slips easily into the pocket provided for this purpose on the inside back cover of No. 111.

The supplement to *Tube-Turn Catalog and Engineering Data Book No. 111* may be had without charge by writing to: Tube Turns, Inc., 224 East Broadway, Louisville 1, Ky.

STAINLESS STEEL HANDBOOK

The selection of the right stainless steel for the application involved is made easy with new *Almet Stainless Steel Handbook*.

An entirely new group of data has been collected and presented in this new 36-page $8^1/_2$- x 11-in. size handbook. Many new innovations have been made for comparing qualities, characteristics, uses, mechanical, physical, electrical, magnetic, heat-resisting and corrosion-resisting properties of stainless steels.

Extensive technical data have been compiled in easy-to-use graphs, charts, tables and comparative form on the proper application of the different stainless steels. Purchasing agents, estimators engineers, research men and production men will all find this new handbook a ready reference for establishing a sound foundation of what stainless steels are, how to fabricate them, and what you can expect of them under many different conditions.

Address Alloy Metal Wire Co., Inc., Prospect Park, Pa.

1948 ANNUAL MEETING OF THE AMERICAN SOCIETY FOR TESTING MATERIALS, DETROIT, JUNE 21–25, INCLUSIVE

The 1948 Annual Meeting of the American Society for Testing Materials, the 51st such session of this national technical organization, is to be held in Detroit the week beginning June 21. During this week there will be some 20 technical sessions, with a large number of technical papers and reports in the field of materials. There will be more than 300 meetings of the Society's technical committees, concentrating their work on standards and research in materials. Throughout the week of the meeting the Society's 8th Exhibit of Testing Apparatus and Related Equipment will be in progress.

One of the most interesting features of the meeting will be the 1948 Edgar Marburg Lecture to be delivered by Dr. Paul Aebersold, Chief of the Isotopes Division, Atomic Energy Commission, Oak Ridge, Tenn. He is expected to discuss the industrial applications of these materials which have such phenomenal prospects for industry and for mankind. This lecture is to be held on Thursday evening, June 24, at the Rackham Memorial Bldg. A cordial invitation is extended to anyone interested to attend this lecture, and also the other technical sessions and the Apparatus Exhibit.

BRONZE WELDING PROCEDURES

The extensive line of bronze welding electrodes engineered and produced by Ampco Metal, Inc., Milwaukee 4, Wis., is fully illustrated and described in Bulletin W-17 entitled, "Welding with Ampco Bronze Electrodes."

Considerable emphasis has been placed in the new bulletin on welding technique and procedures. A comprehensive weldability chart is included showing many diverse types of application with recommendations as to which Ampco bronze electrode to use in each case.

Recommendations are unbiased since Ampco produces electrodes of aluminum bronze, phosphor bronze, beryllium copper and silicon bronze, under the trademark names, Ampco-Trode, Phos-Trode, Beryl-Trode and Sil-Trode, respectively.

Complete information is given regarding each grade or type of Ampco welding electrode. Copies of the new bulletin will be sent on request to welders with difficult welding problems.

WELDING HELPS FOR FARMERS

Welding Helps for Farmers, published by The James F. Lincoln Arc Welding Foundation, Cleveland 1, Ohio, 448 pages, 5¼ x 8⅝ in., 310 illustrations, including photographs and drawings; cover, flexible board covered with parchment cloth simulating leather, gold embossed. Price, postage prepaid United States, $1.00 per copy; elsewhere, $1.50 per copy.

Welding Helps for Farmers is a story of the resourcefulness of farmers working under difficulties, and the book is a handy manual for farm owners who seek ways to save time and work in the future. The examples of mental alertness and of mechanical skills contained within the book are an adequate answer to any person who questions the progressiveness of the nation's rural population.

Stories written by farmers in every area of the nation prove the rapidity of their acceptance of new ways of improving working conditions or working methods. High line electricity and modern welders provided farmers with the means of putting ideas into practical working tools.

Welding Helps for Farmers is a book written by farmers for farmers. The hundreds of ideas, helps, hints and pictures of handy equipment collected in this book were sent in by farmers from every section of the country. Here are described how farmers themselves, without any special training, used arc welding to do such jobs as repairing holes in saucepans, constructing complicated combines, removing rusted nuts, making branding holders for cattle and building all sorts of gadgets.

Directions for learning to arc weld, as well as general welding information, also are given.

The book's 448 pages and its 310 illustrations are divided into 16 sections. The first six sections give general information about the use of welders on farms and also detailed directions for operating an arc welder. The remainder of the book is devoted to stories told by farmers of tools and equipment they build, along with accounts of how the work was done.

Magnesium and Its Alloys*

Compared Metals	Approx. Melt. Pt., °F.	Weight, Lbs. per Cu. In.	Weight, Lbs. per Cu.Ft.	Weight Ratio†	Specific Heat Ratio†	Latent Heat Ratio†	Thermal Conduct. Ratio†	Expansion Ratio†	Modulus in Millions
Magnesium*	1204	0.063	109	1.0	1.0	1.0	1.0	1.0	6.3
Aluminum*	1215	0.098	170	1.54	0.91	1.82	1.4	0.9	10.
Beryllium*	2345	0.066	114	1.06	1.73	6.7	1.04	0.45	42.7
Copper*	1980	0.323	560	5.1	0.36	1.36	2.5	0.62	16
Steel	2700	0.284	490	4.5	0.44	1.27	0.5	0.45	30
18–8 Stainless	2600	0.286	495	4.56	0.48	1.27	0.17	0.63	30
Nickel*	2646	0.322	560	5.1	0.45	1.42	0.38	0.52	30

* Commercially pure metal.
† Approximate ratios—Pure Magnesium = 1.

THE increasing use of magnesium alloys as engineering materials is due to excellent combination of strength-weight characteristics, availability and good fabrication qualities, so that commonly used methods may be utilized.† The alloys may be bent, drawn, blanked, flanged, forged, stretched, spun, sheared, machined and welded. They are available as castings, forgings, bars, plates, sheets and strips, in a wide variety of physical properties, with tensile strengths up to approximately 50,000 psi.‡

Magnesium alloys work-harden rapidly at room temperature, hence only simple forming should be done at these temperatures to avoid cracking. The ability to deform without cracking is greatly increased by working at elevated temperatures (450–700° F.).§ Temperatures above 750° F. are dangerous, since magnesium may be "burned" at the upper end of the "black heat" range. Proper temperature control is therefore of prime importance.

Plates, sheets and tubes may be bent at room temperature if the radius of the bend is not too small. As a general rule, however, heating to a temperature between 450 and 700° F.§ is recommended since ductility increases markedly at elevated temperatures. Heating may be done economically with a blowtorch. Since these alloys have high conductivity they cool rapidly and the use of forms preheated to 300–400° F.§ is advisable in bending.

For drawing operations** dies are ordinarily formed of soft steel and made full-sized to compensate for the greater expansion of magnesium at elevated temperatures. For severe drawing, preheat temperature of 600° F.§ is recommended for the dies and 400–650° F.§ for the magnesium alloy. Draw reductions of over 50% are possible at the latter temperature with proper lubrication, a good lubricant being colloidal graphite in a suitable fluid.**

Danger of cracking in blanking and piercing is lessened by preheating to 500–600° F.,§ which also improves the finished appearance of edges. In flanging, preheating workpiece and flanging tool to 400–600° F.§ is desirable.

Satisfactory press and hammer forgings†† of magnesium alloys are commonly made. Forging of magnesium alloys should be done at 500–700° F.§ with dies preheated to 400–600° F.§ Trimming temperatures of 300–500° F.§ prevent severe edge cracks which may tear the forging.

For stretching, workpiece temperatures of 600–700°F.§ and tool temperatures of 400–500° F.§ are recommended. Spinning operations should be done hot. Heat may be applied by playing a torch against the workpiece to obtain temperatures of 500–700° F.§ Shearing operations are best performed in the range of 500–600° F.§

Welding may be done by the gas or electric method. Preheating temperatures of 500–700° F.§ are necessary to minimize the danger of cracking.

The room temperature properties of annealed magnesium alloys are not appreciably affected by heating if 650° F.§ is not exceeded. However, previously heat-treated or cold-worked material will be influenced by heating, the effect depending on alloy composition, previous treatment and temperature reached.

* From *Tempil Topics*, Feb. 16, 1948.
† Eastwood, L. W., "Economic Aspects in the Use of Aluminum and Magnesium Alloys," *Materials & Methods*, June 1947.
‡ DuMond, T. C., "Magnesium Alloys," *Materials & Methods Manual*, May 1947.
§ Tempilstiks° are a convenient way of checking these temperatures. Sample Tempil° pellets on request.
** Gillespie, Ralph G., "Production Principles for Deep Drawn Magnesium Parts," *Materials & Methods*, March 1946.
†† Rustay, Rote and Wirsing, "Magnesium Alloy Forgings," *Metals and Alloys*, March 1945.